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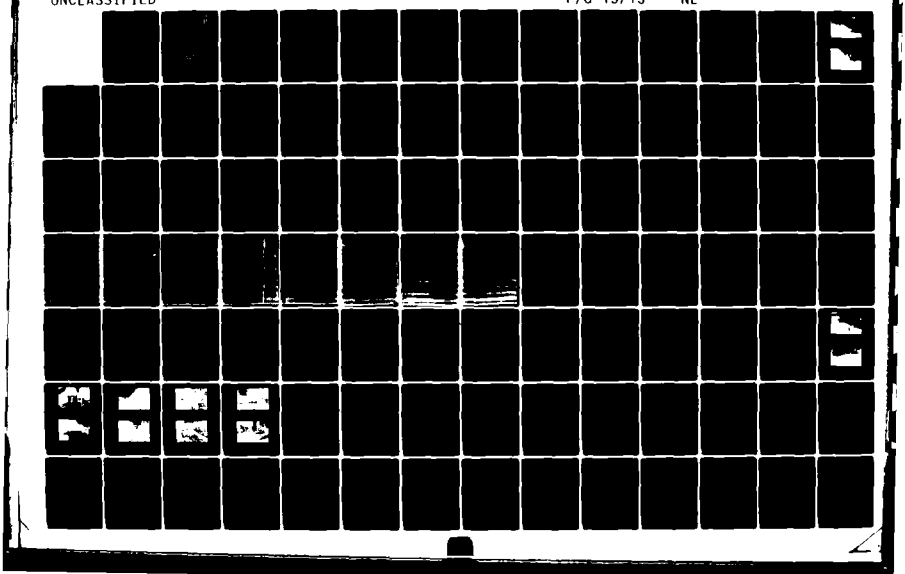
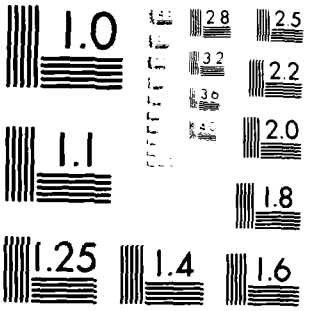
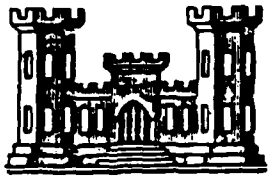




CONNECTICUT RIVER BASIN
NORTHFIELD, MASSACHUSETTS

NORTHFIELD SCHOOL UPPER RESERVOIR DAM
MA 00051

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM



DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS. 02154

APRIL 1981

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

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19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

DAMS, INSPECTION, DAM SAFETY,
Connecticut River Basin
Northfield, Massachusetts

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Northfield School Upper Reservoir Dam is a 45 year old earth embankment dam. The dam is approximately 240 feet long and has a maximum height of about 37 feet. The dam appears to be in fair overall condition. The recommended range of the test flood for a "Small" size, "Significant" hazard dam is from the 100-year flood to ½ the PMF.

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DEPARTMENT OF THE ARMY

NEW ENGLAND DIVISION
424 TRAPELO ROAD
WALTHAM, MASSACHUSETTS 02254

NEDED

Honorable Edward J. King
Governor of the Commonwealth of
Massachusetts
State House
Boston, Massachusetts 02133

Dear Governor King:

Inclosed is a copy of the Northfield Seminal Upper Reservoir Dam (MA-00051) Phase I Inspection Report, prepared under the National Program for Inspection of Non-Federal Dams. This report is based upon a visual inspection, a review of the past performance and a brief hydrological study of the dam. I approve the report and support the findings and recommendations described in Section 7 and ask that you keep me informed of the actions taken to implement them. This follow-up action is vitally important.

Copies of this report have been forwarded to the Department of Environmental Quality Engineering, and to the owner, Northfield - Mt. Hermon School, Physical Plant Office, East Northfield, MA. Copies will be available to the public in thirty days.

I wish to thank you and the Department of Environmental Quality Engineering for your cooperation in this program.

Sincerely,

C. E. EDGAR, III
Colonel, Corps of Engineers
Commander and Division Engineer

Incl
As stated

NORTHFIELD SCHOOL UPPER RESERVOIR DAM
MA 00051

CONNECTICUT RIVER BASIN
NORTHFIELD, MASSACHUSETTS

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

NATIONAL DAM INSPECTION PROGRAM

PHASE I INSPECTION REPORT

Identification No:	MA 00051
Name of Dam:	Northfield School Upper Reservoir Dam (Grandin Reservoir Dam)
Town:	East Northfield
County and State:	Franklin County, Massachusetts
Stream:	Louisiana Brook
Date of Inspection:	December 4, 1980

BRIEF ASSESSMENT

Northfield School Upper Reservoir Dam is a 45-year old earth embankment dam which impounds water for the Northfield - Mt. Hermon School and the Town of East Northfield. The dam is approximately 240 feet long and has a maximum height of about 37 feet. The slope of the upstream face of the dam is about 2.5 H:1V, the top width is approximately 17 feet and the slope of the downstream face is approximately 2H:1V. A gatehouse located on the top of the dam provides access to outlet works for the dam.

The dam appears to be in fair overall condition. No obvious signs of settlement or misalignment are evident; however, clear seepage and erosion are apparent at each of the abutments and at the toe of the dam. Lack of a comprehensive operation and maintenance program is also apparent, as evidenced by the presence of small trees and brush on the dam and large trees in close proximity to the dam. In addition, only one of the outlet valves was found to be operable. (Since the date of inspection, the Owner has notified us that all of the valves have been made operable).

Northfield School Upper Reservoir Dam has a maximum capacity of approximately 104 acre-feet and a maximum height of about 37 feet. These values fall within the ranges specified by the Army Corps of Engineers for "Small" size dams. If Northfield School Upper Reservoir Dam were to fail, it is anticipated that appreciable property damage would result at the hazard area located approximately 0.6 mile downstream of the dam, along with the possible loss of a few lives. Therefore, the hazard classification is "Significant". The recommended range of the test flood for a "Small" size, "Significant" hazard dam is from the 100-year flood to one-half of the Probable Maximum Flood (PMF). Because the height of the dam is close to the upper limit established for "Small" size dams, and because of the potential for appreciable property damage, the selected test flood for the dam assessment is one-half of the PMF.

The test flood peak inflow to Northfield School Upper Reservoir Dam was computed to be approximately 550 cfs. The corresponding outflow was also 550 cfs and resulted in a 0.5 foot depth of flow over the dam. The spillway (with the

flashboards in place) has a discharge capacity of about 180 cfs, or roughly 33 percent of the routed test flood outflow, assuming the reservoir pool is at the top of the dam Assuming the flashboards are removed or fail prior to overtopping of the dam, the spillway capacity would then be apprximately 790 cfs or about 44 percent in excess of the routed test flood outflow.

Within one year after receipt of this Phase I Inspection Report, the Owner, the Northfield-Mt. Hermon School, should retain the services of a qualified, registered professional engineer, experienced in the design and construction of dams, to: 1) investigate the source and nature of clear seepage observed along the downstream side abutment areas and at the toe of the dam eroded areas at these locations should be filled, regraded and reseeded; 2) perform a detailed hydraulic/hydrologic analysis to assess the need for increasing the spillway capacity; 3) direct the removal of trees and their root systems from the embankment and the area to within 20 feet of the toe, including the backfilling of any remaining voids with suitable, thoroughly compacted material; and 4) design and direct the installation of control facilities at the inlets of the mid and low level outlets.

In addition, the Owner should implement the following operation and maintenance procedures: 1) initiate a comprehensive operation and maintenance program, designed to ensure the safe and reliable operation of all operating facilities; 2) initiate a program of annual technical inspection; 3) verify the operability of all outlet valves; 4) remove the flashboards from the spillway; 5) monitor the seepage areas identified in this Report, until such time that an engineer can perform the analyses discussed above; and 6) develop a formal surveiliance and downstream warning system.

O'BRIEN & GERE ENGINEERS, INC.

JOHN JAY WILLIAMS No 30208 (CIVIL)

Date:_____

John J. Williams, P.E.
Vice President
Massachusetts Registration No. 30208

This Phase I Inspection Report on Northfield School Upper Reservoir Dam has been reviewed by the undersigned Review Board members. In our opinion, the reported findings, conclusions, and recommendations are consistent with the Recommended Guidelines for Safety Inspection of Dams, and with good engineering judgement and practice, and is hereby submitted for approval.

JOSEPH W. FINEGAN, JR., MEMBER
Water Control Branch
Engineering Division

ARAMAST MAHTESIAN, MEMBER
Geotechmical Engineering Branch
Engineering Division

CARNEY M. TERZIAN, CHAIRMAN
Design Branch
Engineering Division

APPROVAL RECOMMENDED:

JOE B. FRYAR
Chief, Engineering Division

PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation: however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the Spillway Test flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. Because of the magnitude and rarity of such a storm event, a finding that a spillway will not pass the test flood should not be interpreted as necessarily posing a highly inadequate condition. The test flood provides a measure of relative spillway capacity and serves as an aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

The Phase I Investigation does not include an assessment of the need for fences, gates, no-trespassing signs, repairs to existing fences and railings and other items which may be needed to minimize trespass and provide greater security for the facility and safety to the public. An evaluation of the project for compliance with OSHA rules and regulations is also excluded.

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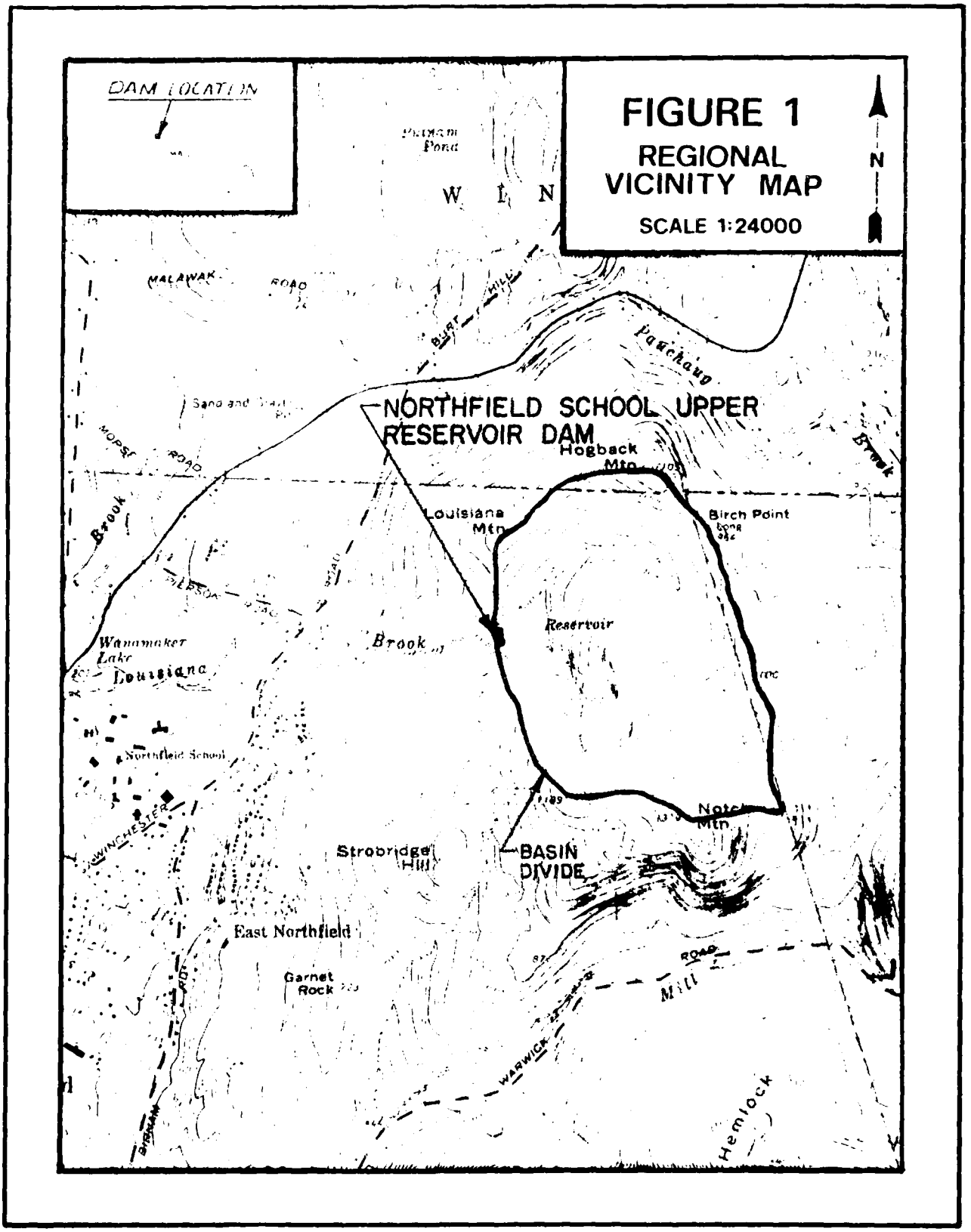
UPSTREAM OVERVIEW OF DAM FROM THE SOUTH ABUTMENT. (12/4/80)

DOWNSTREAM OVERVIEW OF DAM FROM THE SOUTH ABUTMENT (12/4/80)


DAM LOCATION
FIGURE 1
REGIONAL
VICINITY MAP
SCALE 1:24000
N
NORTHFIELD SCHOOL UPPER
RESERVOIR DAM
Hogbock
Mtn
Louisiana
Mtn
Birch Point
Reservoir
Brook
Wanamaker
Lake
Louisiana
Northfield School
Strobridge
Hill
BASIN
DIVIDE
East Northfield
Garnet
Rock
MALAWAK
ROAD
MOPST
ROAD
WINCHESTER
WARWICK
Mill
ROAD
Hemlock
Pachaug

NATIONAL DAM INSPECTION PROGRAM

PHASE I INSPECTION REPORT

SECTION 1

PROJECT INFORMATION

1.1 General

a. Authority. The National Dam Inspection Act (Public Law 92-367) was passed by Congress on August 8, 1972. Under this Act, the Secretary of the Army was authorized to initiate, through the Corps of Engineers, the National Program for Inspection of Dams throughout the United States. Responsibility for supervising inspection of dams in the New England Region has been assigned to the New England Division of the Army Corps of Engineers.

O'Brien & Gere Engineers, Inc. has been retained by the New England Division to inspect and report on selected non-federal dams in Massachusetts. Authorization and Notice to Proceed were issued to O'Brien & Gere by a letter dated November 12, 1980 and signed by Col. William E. Hodgson, Jr. Contract No. DACW-33-81-C-0016 has been assigned by the Corps for this work.

b. Purpose. The purpose of inspecting and evaluating non-federal dams is to:

1. Identify conditions which threaten public safety and make the Owner aware of any deficiencies so that he may correct them in a timely manner;

2. Encourage and prepare the Commonwealth to initiate an effective dam safety program for non-federal dams as soon as possible; and

3. Update, verify and complete the National Inventory of Dams.

1.2 Description of Project (Information for the dam was obtained from the Northfield-Mt. Hermon School, Physical Plant Office and the Massachusetts Department of Environmental Quality Engineering.)

a. Location. Northfield School Upper Reservoir Dam (Grandin Reservoir Dam) is located on Louisiana Brook in the Town of Northfield, Massachusetts. Louisiana Brook originates approximately 1.2 miles southeast of the dam and continues in a westerly direction for a distance of approximately 1.6 miles downstream of the dam. At this point, it drains to Pauchaug Brook which flows in a southwesterly direction for another 0.4 mile to the Connecticut River. To illustrate the location, a portion of the USGS quadrangle map entitled "Northfield, Mass. - N.H. - VT." has been reproduced and included as Figure 1 on page vi of this Report. USGS reference coordinates for this dam are N42°43.2' and W72°25.3'.

b. Description of Dam and Appurtenances. Northfield School Upper Reservoir Dam is a 45-year old earth embankment structure with a concrete core wall. It is approximately 240 feet long and has a maximum height of about 37 feet. The upstream face of the dam is on a slope of about 2.5 H:1V. It is covered with hand-placed riprap to within approximately 1.5 feet of the dam crest. A moderate growth of grass, light brush, and small trees cover the 17-foot wide dam crest and downstream slope of the dam. The downstream face is predominantly sloped at 2H:1V from the dam crest to the tree-covered toe of the dam. The main controls for the dam outlets are housed in a small wooden gatehouse located on the dam crest approximately 90 feet from the northern dam abutment.

A 30-foot wide spillway channel is located at the southern dam abutment. It has an 18-foot long by 30-foot wide approach apron and 2.5-foot high permanent wooden flash boards at the spillway inlet (see photo No. 4, Appendix C). The discharge chute, like the approach apron, has an inlaid stone bottom and concrete training walls. As illustrated on page B-1 of Appendix B, the spillway discharge chute is directed northwesterly and tapers to a 15-foot wide channel prior to discharging into Louisiana Brook approximately 90 feet downstream of the spillway inlet. Also, toward the lower portion of the discharge chute, the outside training wall changes from concrete to stone masonry.

The outlet works for the dam consists of: 1) a 14-inch diameter water supply main, which feeds a small holding reservoir approximately 700 feet downstream of the dam; 2) an 8-inch diameter drain originating at a tee connection to the 14-inch water main about 25 feet downstream of the dam; and 3) a 14-inch diameter low level drain which outlets into Louisiana Brook just downstream of the dam. Two 14-inch diameter pipes with gate valves are used to draw water from Elev. 665 and Elev. 655 in the reservoir to convey water to the supply main. (See page B-3, Appendix B). In addition, two 4-inch diameter pipes emerge from the ground about 10 feet downstream from the outlet of the spillway discharge chute at about Elev. 663 (See Sheet A, Appendix C). The origin of these pipes is not known, but it is suspected that they are part of the toe drain system of the dam.

c. Size Classification. Northfield School Upper Reservoir Dam has a maximum storage capacity of 104 acre-feet and a maximum height of about 37 feet. Because these values lie within the 50 to 1,000 acre-feet storage and 25 to 40 feet of height ranges specified by the Army Corps of Engineers for small size dams, Northfield School Upper Reservoir Dam is classified as "Small".

d. Hazard Classification. Flow resulting from an assumed failure of Northfield School Upper Reservoir Dam would be routed via Louisiana Brook to a residential area located approximately 0.6 mile west of the reservoir. Based upon computer analysis of a hypothetical breach of the dam, it is estimated that one house would experience flooding to a depth of one to two feet above its first floor elevation. It is likely that appreciable damage would result at the house, along with the possible loss of a few lives. Northfield School Upper Reservoir Dam is therefore classified as a "Significant" hazard structure.

e. Ownership. The dam is owned by the Northfield-Mt. Hermon School; Physical Plant Office; East Northfield, Massachusetts. (Tel: 413/498-5311)

f. Operator. Responsibility for operation of the dam is assigned to Mr. David Jakuboski, Director of Physical Plant. Mr. Wayne Black, Superintendent of the Water Department, is involved with the daily operation of the dam and its controls.

g. Purpose of the Dam. The dam was originally constructed to provide a water supply for the Northfield-Mt. Hermon school. Currently, the dam impounds water for a total of approximately 700-800 people at the school and approximately 1,500 people in the Town of East Northfield.

h. Design and Construction History. Northfield School Upper Reservoir Dam was designed in 1933 by Mr. Lewis D. Thorpe of Boston, Massachusetts (see Drawings in Appendix B). Construction was started in 1934 and completed in 1935 by personnel from the Northfield-Mt. Hermon School. Since that time, no major additions to or modifications of the original dam have been made, except for the replacement of the flashboards in the spillway about three years ago.

i. Normal Operating Procedures. The mid-level 14-inch diameter intake gate with an invert at El. 665.0 (shown on page B-3, Appendix B) is normally open while the low level 14-inch diameter intake gate with its invert at El. 655.0 is kept closed. Outflow from the reservoir is controlled by adjusting the opening of the 14-inch diameter gate valves located on the water supply main approximately 35 feet downstream of the dam and at the downstream holding reservoir approximately 700 feet downstream of the dam. In addition, pool elevations for each of the reservoirs are checked daily, but stage records are not kept.

1.3 Pertinent Data

a. Drainage Area. The watershed for Northfield School Upper Reservoir Dam includes approximately 0.6 square mile of very steep and forested terrain lying to the east of the dam. No development is permitted within the watershed area. Louisiana Brook is the drainage area's main watercourse.

b. Discharge at Damsite.

1. Outlet Works. Two known outlets pass through the dam: a) A 14-inch diameter water supply main originates at the base of the concrete well under the gatehouse at El. 654.5. Water is supplied to the main from two 14-inch diameter intake pipes and gates in the concrete well under the gatehouse with inverts of El. 655.0 and El. 665.0. The water supply main conveys water from the concrete well under the gatehouse to a holding reservoir approximately 700 feet downstream of the dam from which water is discharged to the water distribution system. An 8-inch diameter drain on the water supply main with an outlet invert at about El. 650 is located approximately 25 feet downstream of the dam; and b) a 14-inch diameter low level drain for the reservoir with an inlet invert at El. 656$^{\pm}$ in the concrete well under the gatehouse and an outlet invert at the downstream toe of the dam at El. 650$^{\pm}$ is the other outlet. With the reservoir pool at the top of the dam, this drain is capable of passing approximately 20 cfs. This outlet is not indicated on the proposed plans of the dam, but is shown on the 1975 State inspection report included in Appendix B.

2. Maximum Known Flood At Damsite. No records have been kept.

3. Ungated Spillway Capacity at Top of Dam. The capacity of the spillway, assuming that the flashboards are removed to the spillway crest El. 683.5 and the reservoir pool is at top of dam Elevation 687.5, is 790 cfs. Under similar conditions, except with the flashboards in place, the spillway discharge capacity is approximately 180 cfs.

4. Ungated Spillway Capacity at Test Flood Elevation. The ungated spillway capacity with the flashboards removed, at test flood Elevation 688 is 950 cfs. With the flashboards in place, the spillway capacity at test flood elevation 688 is approximately 280 cfs.

5. Gated Spillway Capacity at Normal Pool. N/A

6. Gated Spillway Capacity at Test Flood Elevation. N/A

7. Total Spillway Capacity at Test Flood Elevation. See 1.3.b.4 above. (Note that the flashboards are not easily removable and that it is questionable as to whether or not the flashboards would fail if overtopping of the dam occurred.)

8. Total Project Discharge at Top of Dam. The total project discharge at top of dam Elevation 687.5, including flow through the one of the 14-inch diameter outlets, is approximately 200 cfs with the flashboards in place and approximately 810 cfs with the flashboards removed.

9. Total Project Discharge at Test Flood Elevation. The total project discharge at test flood Elevation 688, including discharge over the spillway, through the low level outlet and over the dam, is approximately 550 cfs with the flashboards in place and approximately 1,200 cfs with the flashboards removed.

c. Elevation (NGVD)

1.	Steambed at Toe of Dam	650.5±
2.	Bottom of Cutoff	Varies
3.	Maximum Tailwater	Unknown
4.	Normal Pool (with Flashboards)	686.0
5.	Full Flood Control Pool	N/A
6.	Spillway Crest (With Flashboards)	686.0
7.	Spillway Crest (Without Flashboards)	683.5
8.	Design Surcharge (Original Design)	Unknown
9.	Top of Dam	687.5
10.	Test Flood Surcharge	688.0

d. Reservoir Length (Feet)

1.	Normal Pool	800
2.	Flood Control Pool	N/A
3.	Spillway Crest (with Flashboards) Pool	800
4.	Top of Dam Pool	850
5.	Test Flood Pool	880

e. Storage (Acre-Feet)

1.	Normal Pool	91
2.	Flood Control Pool	N/A
3.	Spillway Crest (with Flashboards) Pool	91
4.	Top of Dam Pool	104
5.	Test Flood Pool	109

f. Reservoir Surface Area (Acres)

1.	Normal Pool	7.5
2.	Flood Control Pool	N/A
3.	Spillway Crest (with Flashboards) Pool	7.5
4.	Top of Dam Pool	8.8
5.	Test Flood Pool	9.4

g. Dam Data

1.	Type	Earth Embankment
2.	Length	240 feet
3.	Height	37 feet
4.	Top Width	17 feet
5.	Side Slopes (Upstream)	2.5 H:1V
	(Downstream)	2 H:1V
6.	Zoning	Impervious material upstream of concrete core wall and pervious material downstream of the concrete core wall
7.	Impervious Core	Concrete
8.	Cutoff	Extension of impervious concrete wall to tight, impervious foundation material
9.	Grout Curtain	None

h. Diversion and Regulating Tunnel

Not applicable.

i. Spillway (with flashboards)

1.	Type	Stone Masonry Channel (with flashboards)
2.	Length of Weir	30 feet
3.	Crest Stone Masonry, Elevation	683.5
4.	Top of Flashboards, Elevation	686.0
5.	Upstream Channel	30-foot wide approach apron
6.	Downstream Channel	30-foot wide chute at entrance, tapers to 15-foot width in a distance of about 90 feet, sloped at 7.5%, cement mortared stone bottom with concrete training walls

j. Regulating Outlets

1. 14-inch diameter Water Main

a.)	Invert Elevation in the concrete well under the Gatehouse	654.5
b.)	Size	14-inch Diameter
c.)	Description	Bell and Spigot Cast Iron Pipe
d.)	Control Mechanism	Gate Valves (one at Gatehouse and one approximately 30 feet downstream of dam)

2. Reservoir Drain

a.)	Invert Elevation in the concrete well under the Gatehouse	656.0
b.)	Size	14-inch Diameter
c.)	Description	Bell and Spigot Cast Iron Pipe
d.)	Control Mechanism	Gate Valve (one at Gatehouse)

SECTION 2

ENGINEERING DATA

2.1 Design

Design drawings have been reduced and included as pages B-1 through B-4 of Appendix B. According to Mr. Jakuboski, the Owner's representative, no other design information is available.

2.2 Construction

The only available construction information is shown on the drawings included in Appendix B.

2.3 Operation

Under normal operating conditions, water flows by gravity through the 14-inch diameter cast iron mid-level intake pipe to the concrete well under the gatehouse and then to a holding reservoir, located 700 feet downstream of the dam, via a 14-inch diameter cast iron water main. The discharge is controlled by adjusting the opening of one of the gate valves on the water main in order to maintain a relatively constant water level in the holding reservoir. If desired, the operator may close the mid-level gate and draw water from the reservoir via the low level gate. In addition, a 14-inch diameter reservoir drain or an 8-inch diameter drain on the water supply main may be opened for emergency drawdown or maintenance operations. For inverts of the above mentioned pipes, refer to paragraph 1.3.b.

2.4 Evaluation

a. Availability. The drawings included as pages B-1 through B-4 of Appendix B are available from the Director of Physical Plant; Northfield-Mt. Hermon School; East Northfield, Massachusetts. The inspection reports in Appendix B were obtained from the Massachusetts Department of Environmental Quality Engineering.

b. Adequacy. The construction drawings, inspection reports, information obtained from the Owner's representatives and the field inspection, provided adequate information for a Phase I evaluation.

c. Validity. With the exception of the omission of the 14-inch diameter cast iron pipe reservoir drain from the drawings, the information appears to be valid. Where possible, field measurements were made to verify the dimensions indicated on the construction drawings.

SECTION 3

VISUAL INSPECTION

3.1 Findings

a. General. Northfield School Upper Reservoir Dam was inspected on December 4, 1980. At that time, the pool elevation was 5.5 feet below the crest of the flashboards in the spillway. According to the Owner's representative, the water level is normally at or near the top of the flashboards. The prolonged dry weather period has been responsible for the unusually low water level. No underwater areas, other than those which could be seen from above the water surface, were inspected.

The observations and comments of the field inspection team are noted on a checklist included as Appendix A of this report.

b. Dam. The dam is located in a heavily forested, mountainous region. The abutments and downstream toe of the dam are overgrown with coniferous trees. A few deciduous trees, including a few saplings growing on the dam crest, may be observed among the large pine and spruce trees which surround the dam and reservoir.

The dam appears to be in fair overall condition. The upstream face of the dam appears to be adequately protected with riprap. No evidence of settlement or significant structural deterioration was observed; however, clear seepage (about 2 gpm in each location) and erosion were observed at the toe of the dam near the outlet of a 6-inch diameter vitrified clay toe drain pipe and at each of the downstream side abutment areas. The 6-inch diameter toe drain pipe was discharging approximately 1 gpm at the time of the inspection. A similar quantity of seepage was observed flowing from a slightly eroded area surrounding the outlet.

The downstream side abutments are each eroded at the seepage areas indicated on Sheet A of Appendix C. Seepage at the north side abutment has created a very soft and slightly eroded area appoximately 6 feet wide and 10 feet long. The seepage toward the top of the dam at the south side abutment has created a similar, but more eroded area. The area is approximately 10 feet wide, 20 feet long, and has a 1.5 foot depression at the upstream end, where the embankment has been eroded away.

Several trees, ranging in size up to approximately 12 inches in diameter, were observed growing at the downstream toe of the dam. Further downstream of the dam, near the outlet of the spillway chute, two 4-inch diameter pipes were observed. These pipes were dry at the time of the inspection. The locations of the outlet works are illustrated on Page C-1 of Appendix C.

c. Appurtenant Structures. A wooden gatehouse, which is located on the dam crest approximately 90 feet from the northern dam abutment, provides access to two intake gate operators and one low level outlet gate operator. This arrangement is not desirable, since the outlet pipes upstream of the gatehouse are continuously under pressure. The gatehouse has a 32-foot deep concrete well, which

was observed to have superficial spalling at its exposed exterior corners. To discourage vandalism, windows have not been installed in the gatehouse.

A 30-foot wide spillway is located at the southern dam abutment. The spillway inlet has an 18-foot long by 30-foot wide approach apron, 2.5-foot high wooden flashboards, and a 90-foot long discharge chute which tapers from 30 feet wide to 15 feet wide at its outlet. The entire spillway system is in good condition, except for several trees overhanging the discharge chute and it appears that the flashboards would not fail prior to overtopping of the dam. Several photos of the appurtenant structures are included in Appendix C.

d. Reservoir Area. The watershed consists of approximately 0.6 square miles of steep and forested terrain. Minor erosion could be observed along the tree-lined banks of the reservoir, but no significant accumulations of silt were observed. Development has not been permitted in the watershed area.

e. Downstream Channel. The discharge channel just downstream of the spillway chute leading to Louisiana Brook is free of debris, as shown on photo no. 8 of Appendix C. The brook itself is very small and well defined, but overgrown with brush and trees along its banks. No significant flow restrictions are evident along the channel until it reaches a 4-foot square box culvert at Winchester Road, approximately 3,000 feet downstream of the dam.

3.2 Evaluation

The dam is considered to be in fair overall condition. The seepage and erosion areas should be closely monitored, a more comprehensive operation and maintenance program, including periodic removal of brush and trees from the dam and areas in close proximity of the dam, should be instituted, and valves should be installed at the inlets of the mid and low level outlets.

SECTION 4

OPERATION AND MAINTENANCE PROCEDURES

4.1 Operation Procedures

a. General. Normal operation includes gravity flow of water from the reservoir via the mid-level 14-inch diameter cast iron intake pipe to the concrete well under the gatehouse. In the well water enters another 14-inch diameter cast iron pipe which conveys the discharge to a holding reservoir located approximately 700 feet downstream of the dam. According to the Operator, a constant level is maintained at the holding reservoir by adjusting the opening of gate valves located on the 14-inch diameter water main. The only other operating procedure consists of checking the daily pool levels; however, stage records are not kept.

b. Description of any Warning System in Effect. According to the Owner's representative, the dam would be monitored during an extended period of rapid snowmelt and/or rainfall. Residents in the downstream hazard area would be notified if the water level approached the top of the dam. No formal warning system has been established.

4.2 Maintenance Procedures

a. General. According to the Owner's representative, maintenance is performed as needed. No formal maintenance program has been established.

b. Operating Facilities. At the time of inspection, only the mid-level intake gate was found to be operable. Since that time, however, the Owner's representative has informed us that all of the valves have been exercised and now appear to be in good condition. No routine maintenance of operating facilities is performed.

4.3 Evaluation

Existing operation and maintenance procedures should be improved through the implementation of a more comprehensive program. Periodic maintenance should be performed to keep the dam clear of extraneous growth and to ensure reliable operation of the outlet works. In addition, a formal downstream warning system should be developed and annual technical inspections by qualified, registered engineers should be performed.

SECTION 5

EVALUATION OF HYDRAULIC/HYDROLOGIC FEATURES

5.1 General

Northfield School Upper Reservoir Dam has a steep, forested, watershed ranging from El. 1319 at Notch Mountain to El. 686 at the normal pool elevation. Louisiana Brook, the main watercourse to the Reservoir, originates approximately 1.2 miles to the southeast of the reservoir and flows in a westerly direction to the reservoir and, ultimately, to the Connecticut River. The normal storage in Northfield School Upper Reservoir is approximately 91 acre-feet.

5.2 Design Data

According to a letter to the State from former Director of Physical Plant, Carl A. Pelzel, the original flashboards in the spillway were designed to fail when a predetermined overtopping depth is experienced. (See pages B-18 and B-19, Appendix B.) However, the current flashboards were constructed approximately three years ago and may not conform to the original design of failing when a predetermined overtopping depth is experienced. No further hydraulic/hydrologic information is available, according to the current Director of Physical Plant.

5.3 Experience Data

Personnel from the Northfield - Mt. Hermon School check the reservoir pool elevation daily, but stage records are not kept.

5.4 Test Flood Analysis

The recommended test flood range for a "Small" size, "Significant" hazard dam is from the 100-year design storm to one-half of the probable maximum flood (PMF). Because the height of the dam is close to the upper limit of 40 feet established for a "Small" size dam and the potential for appreciable property damage at a residence located about 150 feet downstream Winchester Road, the selected test flood is one-half of the PMF.

Hydraulic and hydrologic calculations were performed with the assistance of HEC-1-DB computer program. Flood hydrographs were developed from Snyder unit hydrographs using average coefficients, an initial infiltration value of zero and a constant loss rate of 0.05 inches per hour. The test flood runoff was reduced according to the "Hop Brook" reduction factor[1], a hypothetical value which takes into account the size of the drainage area and the probability of the storm area coinciding with the drainage area. The routing analysis consisted of constructing the inflow hydrograh for the test flood and routing it over the dam. Stage vs. discharge and stage vs. storage relationships were developed to obtain the outflow hydrograph. The reservoir pool was assumed to be at the crest of the flashboards at the beginning of the test flood storm event.

[1] Corps of Engineers, Engineering Circular No. 1110-2-27, Aug' 66

The peak test flood inflow to Northfield School Upper Reservoir was computed to be approximately 550 cfs (920 csm). The peak test flood outflow was also 550 cfs and resulted in a 0.5-foot depth of flow over the dam. The spillway (with the flashboards in place) has a discharge capacity of about 180 cfs, or roughly 33 percent of the routed test flood outflow, assuming the reservoir pool is at the top of the dam.

Assuming the flashboards are removed or fail prior to overtopping the the dam, the spillway capacity would then be aproximately 790 cfs or about 44 percent in excess of the routed test flood outflow.

5.5 Dam Failure Analysis

Failure of the dam was simulated through the use of the HEC-1-DB computer program. This failure was assumed to be 60 feet wide by 31 feet deep and was initiated when the resevoir pool elevation reached the top of the dam during a 0.13 PMF storm event. The quantity of breach discharge for this size dam is very sensitive to the duration over which the breach is assumed to develop. Therefore, two durations were evaluated: 1) a 15-minute breach and 2) a 1.5-hour breach. For the purposes of this report, breach discharges corresponding to the 15-minute duration breach are discussed. The discharge resulting from the breach was routed along Louisiana Brook for a distance of approximately 0.6 mile to a 4-foot square box culvert under Winchester Road.

Just prior to failure of the dam, a discharge of approximately 260 cfs would be experienced at the Winchester Road culvert. The corresponding pool surface upstream of the road culvert was computed to be at El. 387.8, or just below the road surface. As a result of the simulated dam failure, a peak discharge of 5,490 cfs, with a maximum stage of El. 391.4 was computed at Winchester Road (3.4 feet over the road).

Such a discharge would result in a depth of flow of between one and two feet at a residence located approximately 150 feet downstream of Winchester Road and would cause appreciable property damage, with the possible loss of a a few lives. According to Corps criteria, the damage potential for failure of the Northfield School Upper Resevoir Dam places the dam in the "Significant" hazard classification.

SECTION 6

STRUCTURAL STABILITY

6.1 Visual Observations

The dam was observed to be in fair overall condition. No obvious signs of settlement or structural movement of the dam were observed. Minor spalling was observed at the corners of the gatehouse, but no structural deficiencies were observed. The interior walls of the gatewell were not examined; however, Mr. Wayne Black, Water Superintendent, believes the walls are in good condition.

Clear seepage was observed at the groin areas of each abutment and at the toe of the dam near the outlet of the 6-inch diameter toe drain pipe. In each location, the seepage was estimated to be about two gallons per minute of clear flow; however, moderate erosion and extremely soft ground conditions were observed at the abutment locations. The area around the toe drain outlet is slightly eroded. The seepage warrants further investigation.

6.2 Design and Construction Data

Plans of the dam and its appurtenances are included in Appendix B. According to Mr. Jakuboski, further information is not available.

6.3 Post Construction Changes

The only known modification was made about three years ago when new flashboards were installed in the spillway. No plans exist for that construction, according to Mr. Jakuboski.

6.4 Seismic Stability

Northfield School Upper Reservoir Dam is located in Seismic Zone 2 on the "Seismic Zone Map of Contiguous States." Therefore, according to the "Recommended Guidelines for Phase I Dam Inspections," the dam need not be evaluated for seismic stability.

SECTION 7

ASSESSMENT, RECOMMENDATIONS AND REMEDIAL MEASURES

7.1 Dam Assessment

a. Condition. From visual inspection, it appears that the dam is in fair overall condition. Potentially serious conditions exist at each of the abutments and at the toe of the dam, where clear seepage (about 2 gpm in each location) and erosion have been observed. The remainder of the dam appears to be structurally sound, but the presence of trees on and close to the dam suggest that maintenance should be performed on a more regular basis. The flashboards at the spillway inlet appear to be permanent and severely restrict the spillway capacity. Infrequent exercising of valves on the outlet works was identified as an operational deficiency.

b. Adequacy of Information. The visual inspection, along with the information provided by the Director of Physical Plant at the Northfield - Mt. Hermon School, and inspection reports provided by the Massachusetts Department of Environmental Quality Engineering, proved adequate for a Phase I evaluation of Northfield School Upper Reservoir Dam.

c. Urgency. The recommendations and remedial measures described in this Section should be implemented within one year of receipt of the Phase I Inspection Report.

7.2 Recommendations

The Owner, the Northfield - Mt. Hermon School, should retain the services of a qualified, registered professional engineer, experienced in the design and construction of dams, to:

1. Investigate the source and nature of the seepage observed along the downstream side abutment areas and at the toe of the dam and recommend appropriate corrective measures. Eroded areas at those locations should be filled, regraded and reseeded.

2. Perform a detailed hydraulic/hydrologic analysis to assess the need for increasing the spillway capacity.

3. Direct the removal of trees and their root systems from the embankment and the area to within 20 feet of the toe and direct the backfilling of any remaining voids with suitable, thoroughly compacted material.

4. Design and direct the installation of control facilities at the inlets of the mid and low level outlets.

Recommendations of the engineer should be implemented by the Owner as soon as practicable.

7.3 Remedial Measures

The following operation and maintenance procedures should be implemented by the Owner:

1. Initiate a comprehensive operation and maintenance program, designed to keep the dam free of extraneous growth and ensure the safe and reliable operation of all operating facilities.

2. Initiate a program of annual technical inspection.

3. Verify the operability of all outlet valves.

4. Immediately remove the flashboards from the spillway.

5. Monitor the seepage areas identified in the report, until such time that an engineer can perform the analyses discussed in Section 7.2.

6. Develop a formal surveillance and downstream warning system.

7.4 Alternatives

No valid alternatives to the recommendations and remedial measures described above are considered feasible for this site.

APPENDIX A

CHECKLIST
VISUAL INSPECTION

VISUAL INSPECTION CHECK LIST

INSPECTION TEAM ORGANIZATION

Project: Grandin Reservoir Dam (Northfield School Upper Reservoir Dam)

National I.D.#: MA 00051

Location: Northfield, Massachusetts

Type of Dam: Earth Embankment

Inspection Date(s): December 4, 1980

Weather: Partly Cloudy, Cool

Pool Elevation: 680.5± NGVD*

Inspection Team

Lee DeHeer	O'Brien & Gere	Managing Engineer
Leonard Beck	O'Brien & Gere	Structures
Steven Snider	O'Brien & Gere	Foundations & Materials
Alan Hanscom	O'Brien & Gere	Structures
Denis Mehu	Bryant & Associates	Hydrology/Hydraulics

Owner's Representative

Mr. David Jakuboski, Director of Physical Plant;

Northfield School; East Northfield, Massachusetts

(Tel.: 413/498-5311)

*Estimated from an assumed spillway crest (permanent flashboard) elevation of 686.± indicated on the "Northfield, Mass. - N.H. - Vt." USGS map.

VISUAL INSPECTION CHECK LIST

Project: Grandin Reservoir Dam (Northfield School Upper Reservoir Dam)

National I.D. #: MA 00051

Date(s): December 4, 1980

AREA EVALUATED	CONDITIONS
DAM EMBANKMENT	
Crest Elevation	687.5 NGVD
Current Pool Elevation	680.5 NGVD
Maximum Impoundment to Date	Unknown
Surface Cracks	None Observed
Pavement Condition	NA
Movement or Settlement of Crest	None Observed
Lateral Movement	None Observed
Vertical Alignment	Appears to be good
Horizontal Alignment	Appears to be good
Condition at Abutment and at Concrete Structures	Generally, good at spillway walls. Some cracking at NW corner of gatehouse.
Indications of Movements of Structural Items on Slopes	None Observed
Trespassing on Slopes	No indications observed
Vegetation on Slopes	Moderate brush growth on d/s slope and at west side abutment.
Sloughing or Erosion of Slopes or Abutments	Sloughing observed at top of rip-rap on u/s slope and at groin areas.
Rock Slope Protection - Riprap Failures	Entire u/s face is paved per drawings. Minor displacement of rip-rap toward crest of dam on u/s face.

VISUAL INSPECTION CHECK LIST

Project: Grandin Reservoir Dam (Northfield School Upper Reservoir Dam)

National I.D. #: MA 00051

Date(s): December 4, 1980

AREA EVALUATED	CONDITIONS
DAM EMBANKMENT (Con't)	
Unusual Movement or Cracking at or near Toes	Sloughing observed at each groin area near the toe of the embankment.
Unusual Embankment or Downstream Seepage	Seepage at each groin area toward toe of dam and around sides of toe drains.
Piping or Boils	None Observed
Foundation Drainage Features	Toe Drains (see Appendix B)
Toe Drains	" " " " "
Instrumentation System	NA

VISUAL INSPECTION CHECK LIST

Project: Grandin Reservoir Dam (Northfield School Upper Reservoir Dam)

National I.D. #: MA 00051

Date(s): December 4, 1980

AREA EVALUATED	CONDITIONS
OUTLET WORKS - SPILLWAY WEIR, APPROACH AND DISCHARGE CHANNELS	
a. Approach Channel (Approach Apron)	18'± length - exposed during inspection.
General Condition	Very good.
Loose Rock Overhanging Channel	None observed.
Trees Overhanging Channel	None observed.
Floor of Approach Channel	Stone Masonry - very good condition.
b. Weir and Training Walls (Discharge Channel)	
General Condition of Concrete	Good.
Rust or Staining	None observed - Moss covered in some places.
Spalling	Minor spalling observed.
Any Visible Reinforcing	None observed.
Any Seepage or Efflorescence	None observed.
Drain Holes	None observed.
c. Discharge Channel	
General Condition	Good.

VISUAL INSPECTION CHECK LIST

Project: Grandin Reservoir Dam (Northfield School Upper Reservoir Dam)

National I.D. #: MA 00051

Date(s): December 4, 1980

AREA EVALUATED	CONDITIONS
OUTLET WORKS - SPILLWAY WEIR, APPROACH AND DISCHARGE CHANNELS (Con't)	
Loose Rock Overhanging Channel	None observed.
Trees Overhanging Channel	Several, mostly coniferous, on east side of spillway channel.
Floor of Channel	Stone Masonry
Other Obstructions	None observed.

VISUAL INSPECTION CHECK LIST

Project: Grandin Reservoir Dam (Northfield School Upper Reservoir Dam)

National I.D. #: MA 00051

Date(s): December 4, 1980

AREA EVALUATED	CONDITIONS
OUTLET WORKS - INTAKE CHANNEL AND INTAKE STRUCTURE	
a. Approach Channel	NA
Slope Conditions	(Water enters gatehouse chamber via one of two 14-inch diameter intake pipes. See Appendix B.)
Bottom Conditions	
Rock Slides or Falls	
Log Boom	
Debris	
Condition of Concrete Lining	
Drains or Weep Holes	
b. Intake Structure (Gatehouse)	
Condition of Concrete	Exterior cracking observed at NW corner.
Stop Logs and Slots	NA

VISUAL INSPECTION CHECK LIST

Project: Grandin Reservoir Dam (Northfield School Upper Reservoir Dam)

National I.D. #: MA 00051

Date(s): December 4, 1980

AREA EVALUATED	CONDITIONS
OUTLET WORKS - CONTROL TOWER	
a. Concrete and Structural	
General Condition	Good
Condition of Joints	NA
Spalling	Moderate at NW corner of gatehouse
Visible Reinforcing	None Observed
Rusting or Staining of Concrete	Minor Staining Observed
Any Seepage or Efflorescense	None Observed
Joint Alignment	Alignment appears to be good
Unusual Seepage or Leaks in Gate Chamber	Unknown
Cracks	Exterior cracking observed at NW corner of gatehouse
Rusting or Corrosion of Steel	None observed
b. Mechanical and Electrical	
Air Vents	No mechanical ventilation
Float Wells	None
Crane Hoist	NA

VISUAL INSPECTION CHECK LIST

Project: Grandin Reservoir Dam (Northfield School Upper Reservoir Dam)

National I.D. #: MA 00051

Date(s): December 4, 1980

AREA EVALUATED	CONDITIONS
OUTLET WORKS - CONTROL TOWER (Con't)	
Elevator	None
Hydraulic System	NA
Service Gates	Three sluice gates - operable
Emergency Gates	Made operable after date of inspection
Lighting Protection System	Unknown
Emergency Power System	NA
Wiring and Lighting System in Gate Chamber	None

VISUAL INSPECTION CHECK LIST

Project: Grandin Reservoir Dam (Northfield School Upper Reservoir Dam)

National I.D. #: MA 00051

Date(s): December 4, 1980

AREA EVALUATED	CONDITIONS
OUTLET WORKS - TRANSITION AND CONDUIT	
General Condition of Concrete	No Headwall
Rust or Staining on Concrete	NA
Spalling	NA
Erosion or Cavitation	Erosion observed at outlet (see photos, Appendix C)
Cracking	NA
Alignment of Monoliths	NA
Alignment of Joints	NA
Numbering of Monoliths	NA

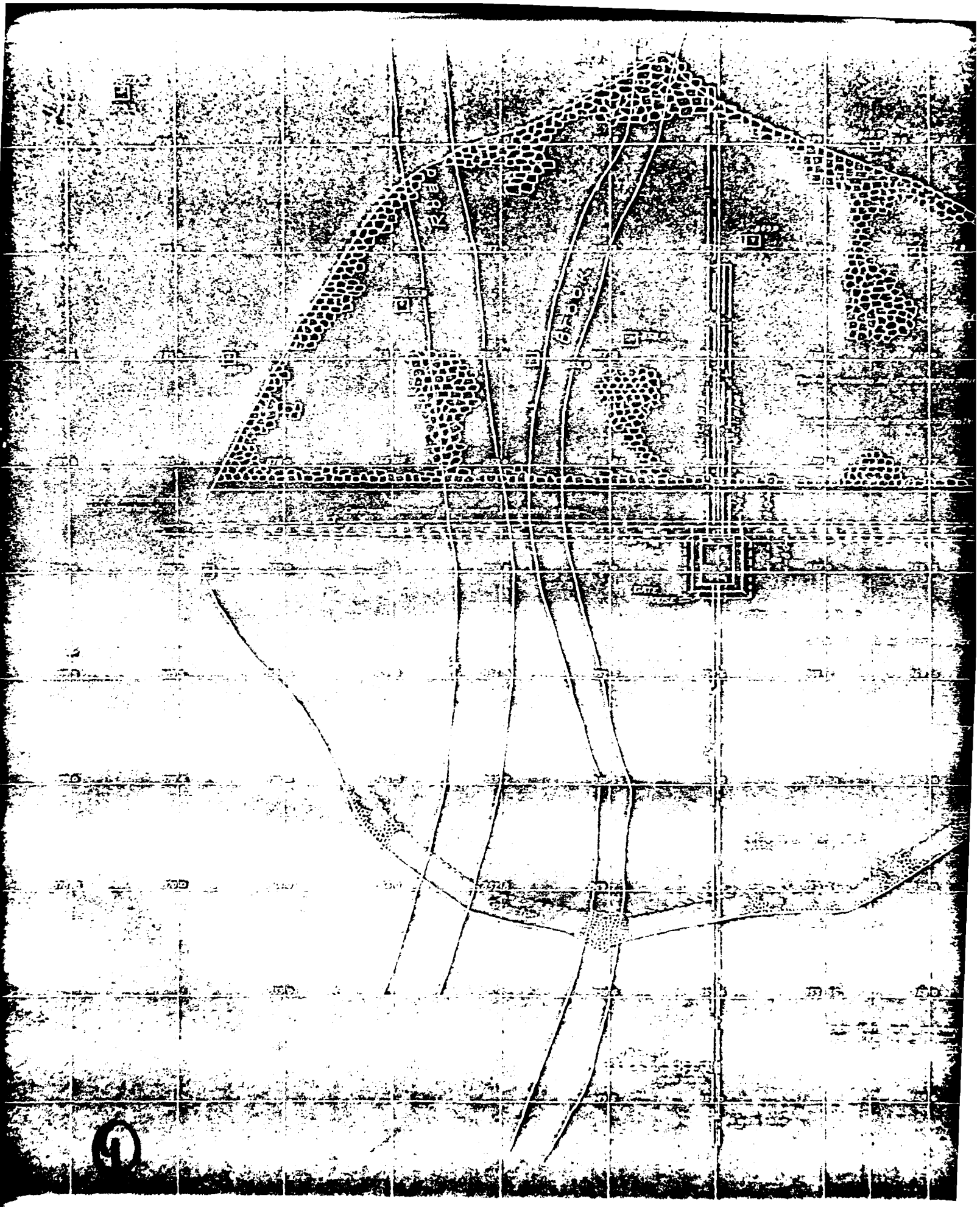
APPENDIX B

CHECKLIST
ENGINEERING DATA

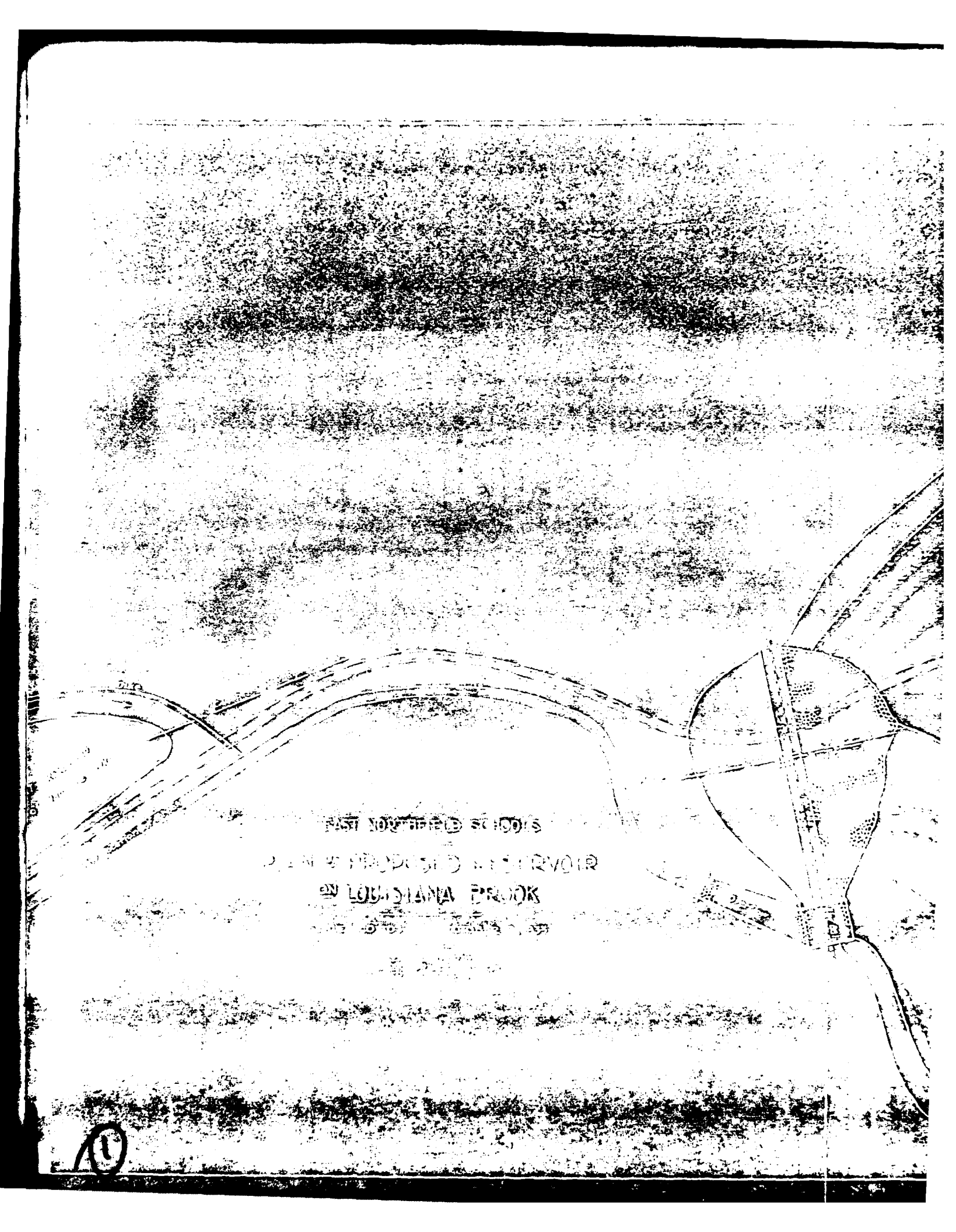
APPENDIX B
ENGINEERING DATA*

TABLE OF CONTENTS

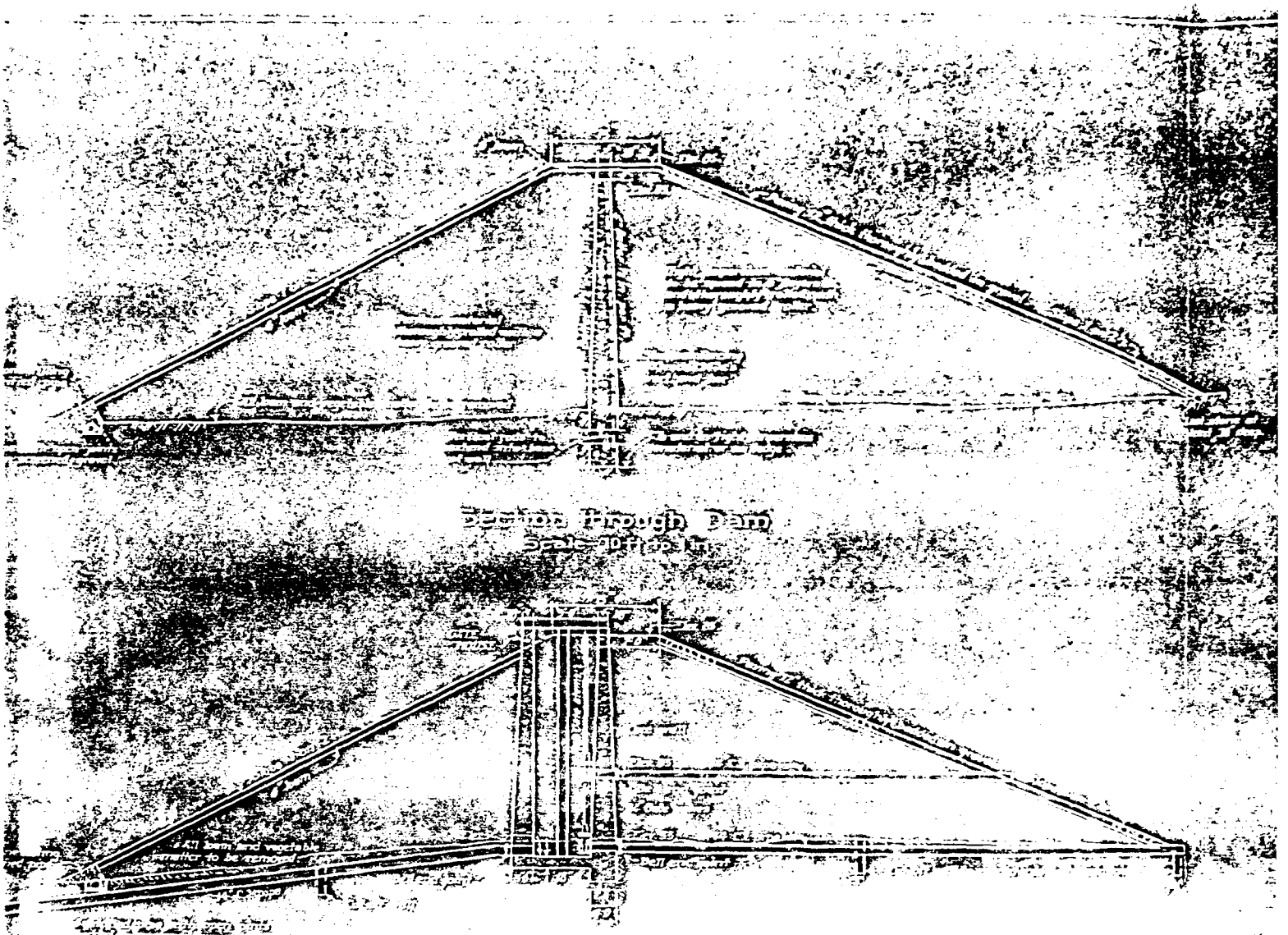
*Drawings of the dam were obtained from the Northfield School, Director of Physical Plant. Miscellaneous information has been obtained from the Massachusetts DEQE files.




CROSS SECTION
PROPOSED LOUISIANA PAD
SCALE: 10 FT = 1 IN
B-1

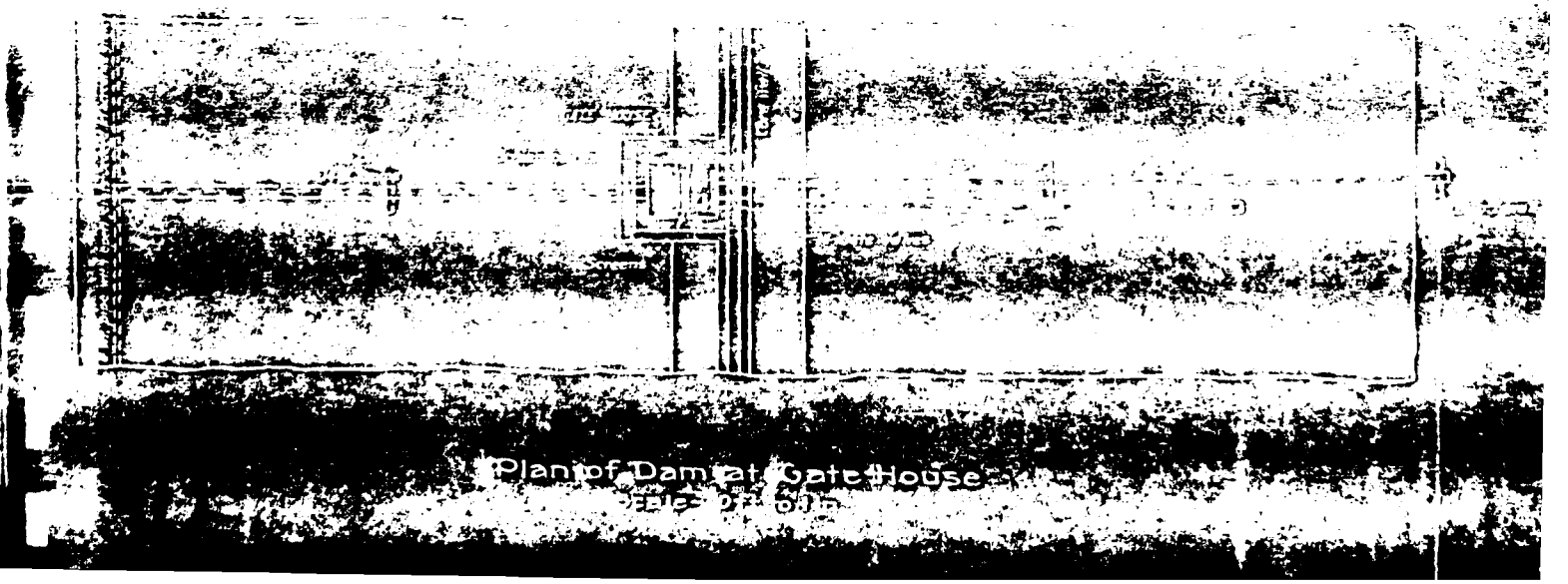

EAST NORTHFIELD SCHOOLS
PLAN OF PROPOSED RESERVOIR
ON LOUISIANA BROOK


Area 75+ Acres
Capacity 28 Mil. Gals.

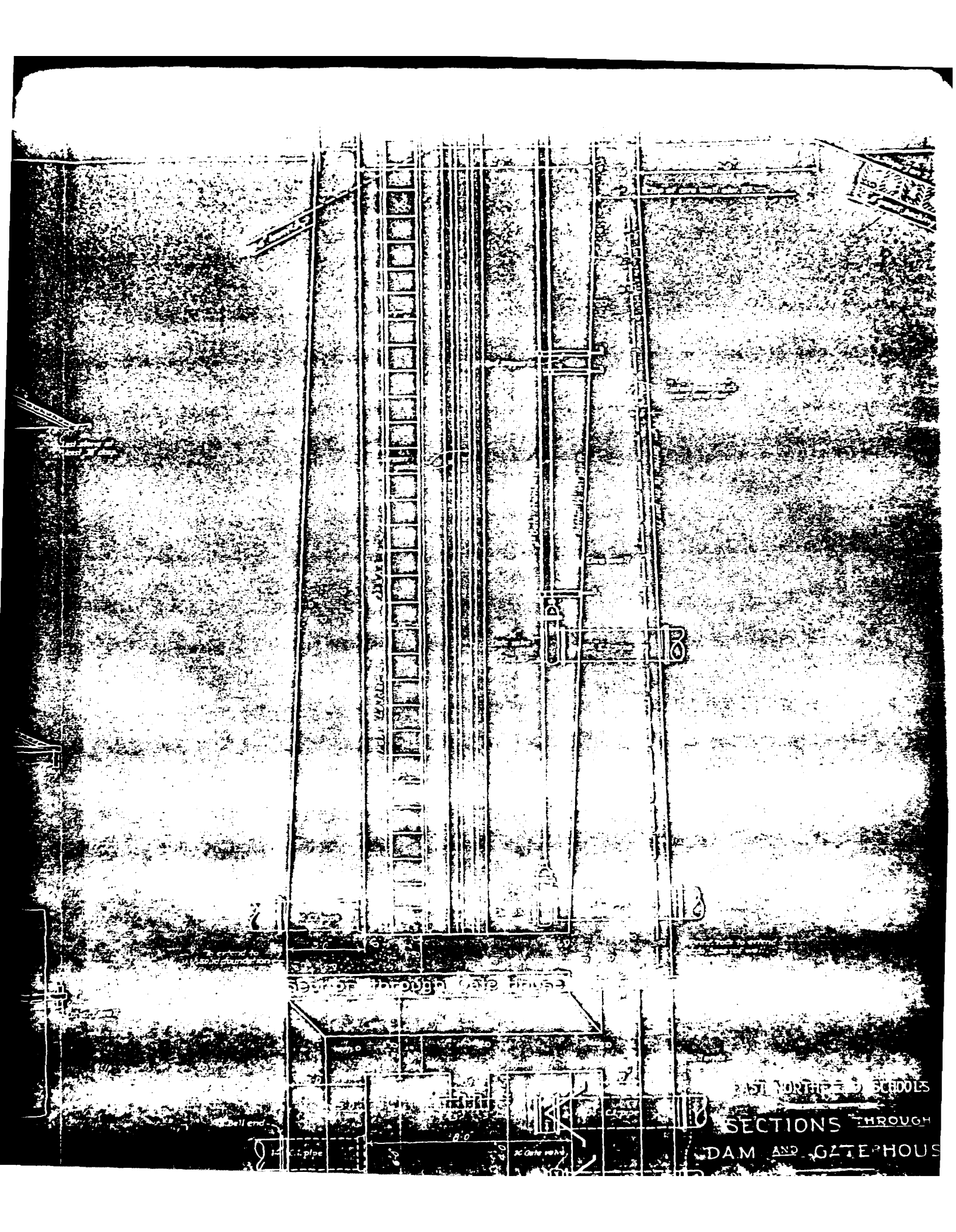


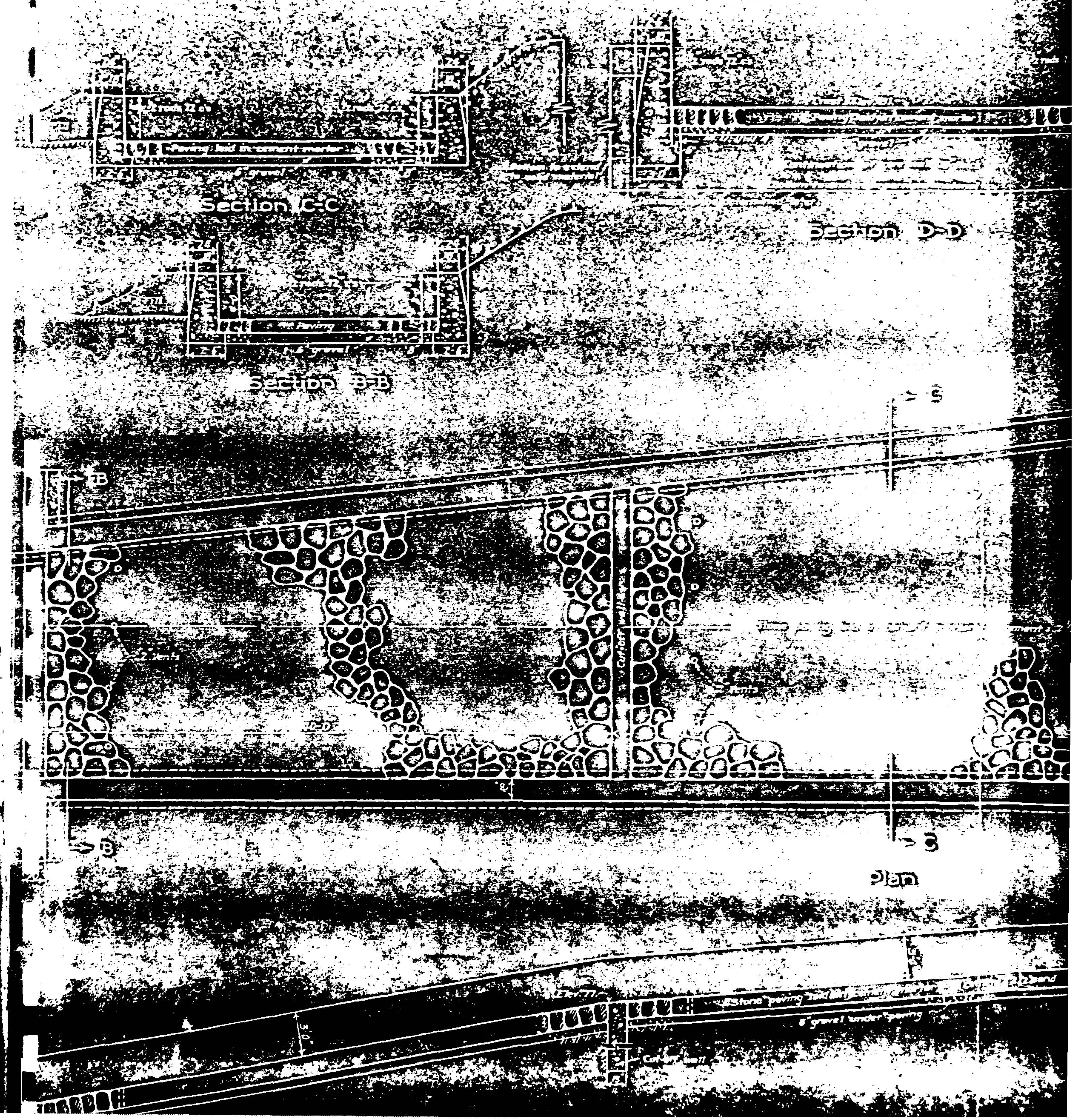
Section through Dam

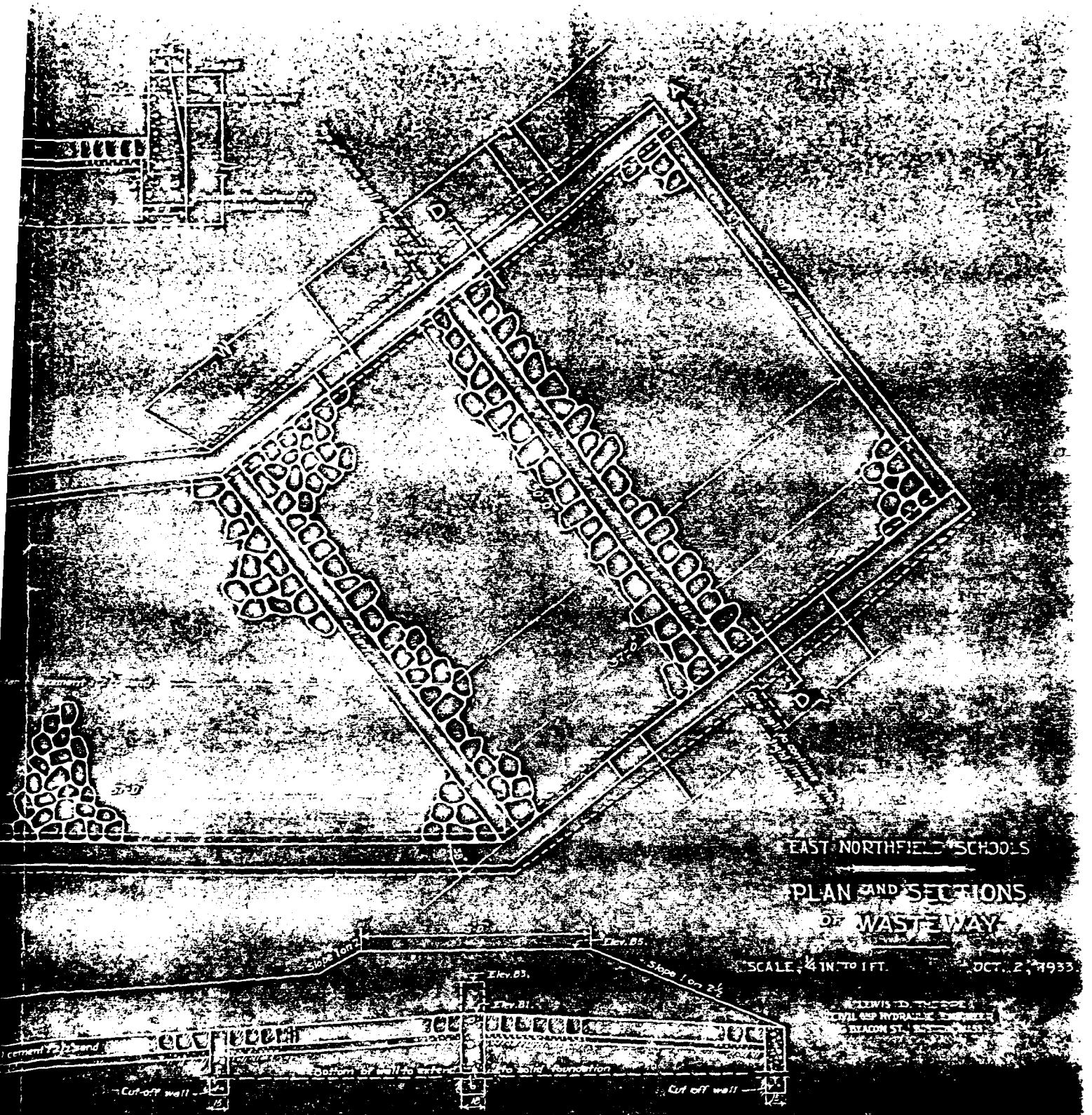
Section through Dam at Gate House



Plan of Dam at Gate House


SECTIONS THROUGH
DAM AND GATEHOUS


Paving laid in cement mortar
6" gravel
Section C-C
Section D-D
Section B-B
B
B
Plan
Stone paving
6" gravel under paving


EAST NORTHFIELD SCHOOLS
PLAN AND SECTIONS
OF WASTEWAY
SCALE, 1/4 IN. TO 1 FT.
OCT. 2, 1933.
LEWIS D. THEOPOLD
CIVIL AND HYDRAULIC ENGINEER
BEACON ST.
Elev. 85.
Slope 1 on 2½
Elev. 83.
Elev. 81.
Slope 1 on 2½
Bottom of all the sewer
No solid foundation
Cut-off wall
Cut off wall

Section A-A

INSPECTION REPORT - DAMS AND RESERVOIRS

1. LOCATION:

~~City~~/Town Northfield. County Franklin. Dam No. 2-6-217-4.

Name of Dam Northfield School Upper "Main" Reservoir Dam.

Topo Sheet No. 134. Mass. Rect. Coordinates: N 627,900, E 351,900.

Inspected by: Harold T. Shumway, On Sept. 23, 1977. Date Last Inspection 11/18/75.

2. OWNER/S: As of September 23, 1977

per: Assessors_____, Reg. of Deeds_____, Prev. Insp. X, Per. Contact X.

	Name	St. & No.	City/Town	State	Tel. No.
1.	Northfield, Mt. Hermon School,		Northfield, Mass.		
2.					
3.					

3. CARETAKER: (if any) e.g. superintendent, plant manager, appointed by absentee owner, appointed by multi owners.

Mr. Reynold Henry
Director of Physical Plant, Northfield School, East Northfield, Mass. 498-5311 ext. 244

Name	St. & No.	City/Town	State	Tel. No.

4. DATA:

No. of Pictures Taken None. Sketches See description of Dam.
Plans, Where Infiles of Physical Plant Office on School Grounds.

5. DEGREE OF HAZARD: (if dam should fail completely)*

1. Minor_____.
2. Moderate_____.
3. Severe X.
4. Disastrous_____.

Comments: Approx. 25 million gallons impoundment-failure could affect streets and homes a short distance downstream.

*This rating may change as land use changes (future development).

(6) OUTLETS: OUTLET CONTROLS AND DRAWDOWN

No. 1 Location and Type: South end of dam-concrete and stone masonry side chute overflow spillway-30' w x 4' h x 134'l.

Controls Yes, TYPE: 2'8" x 3" x 30' flashboards.

Automatic ____. Manual X. Operative Yes X, No ____.

Comments: 1" I.P. stanchions for flashboards designed to fail at certain pressures.

No. 2 Location and Type: Approx. center of dam-gate well intake structure. Intake pipes-2 ea. 14" dia. C.I. outlet pipes 1 ea. 14" diam. C.I. water main-1 ea. 14" pipe blow-off.

Controls Yes, Type: Gate valves on all pipes.

Automatic ____. Manual X. Operative Yes X, No ____.

Comments: Minor spalling of concrete on foundation walls of gatewell. 14" diam. blow-off pipe not shown on proposed plans of dam.

No. 3 Location and Type: ____.

Controls ____, Type: ____.

Automatic ____. Manual ____. Operative Yes ____, No ____.

Comments: ____.

Drawdown present Yes X, No ____. Operative Yes X, No ____.

Comments: Operable per word of maintenance personnel.

(7.) DAM UPSTREAM FACE: Slope 2½:1, Depth Water at Dam 2'8" to top flashboards.

Material: Turf X. Brush & Trees ____. Rock fill ____. Masonry ____. Wood ____.

Other 12" stone paving bedded in gravel.

Condition: 1. Good X. 3. Major Repairs ____.

2. Minor Repairs ____. 4. Urgent Repairs ____.

Comments: ____.

(8.) DAM DOWNSTREAM FACE: Slope 2:1.

Material: Turf X. Brush & Trees ____. Rock Fill ____. Masonry X (Conc. & Stone Spillway). Wood ____.

Other ____.

Condition: 1. Good ____. 3. Major Repairs ____.

2. Minor Repairs ____. 4. Urgent Repairs ____.

Comments: Slope has been cleared of brush & tree growth-growth still exists along toe of slope-seepage flows heavy-see remarks.

EMERGENCY SPILLWAY: Available Yes . Needed .

Height Above Normal Water Unknown Ft. Flashboards in place 2'8" high at entrance to chute

Width 30 Ft. Height 4 Ft. Material conc. walls-conc. & stone paved floor.

Condition: 1. Good . 3. Major Repairs .

2. Minor Repairs X . 4. Urgent Repairs .

Comments: Minor weed and grass growth noted in small crevices existing in stone paved floor.

10. WATER LEVEL AT TIME OF INSPECTION: 5 Ft. Above . Below X .

Top Dam X F.L. Principal Spillway .

Other .

Normal Freeboard 1'-4" Ft. with flashboards in place.

11. SUMMARY OF DEFICIENCIES NOTED:

Growth (Trees and Brush) on Embankment None found on slopes or top of embankment.

Animal Burrows and Washouts None found .

Damage to Slopes or Top of Dam None found .

Cracked or Damaged Masonry Minor spalling of concrete intake well.

Evidence of Seepage Seepage flow noted approx. 30'± north and somewhat higher in elev. than outlet end of 6 inch V.C. pipe located at toe of slope. Questionable-see seepage above and leaks below.

Evidence of Piping A flow of several G.P.M. was emerging from outlet end of 6 inch V.C. pipe.

Leaks at toe of slope-origin of pipe unknown-small flow also noted along side of pipe. See remarks.

Erosion None found .

Trash and/or Debris Impeding Flow None found .

Clogged or Blocked Spillway None found .

Other .

DAM NO. 2-6-217-4

12) OVERALL CONDITION:

1. Safe_____.
2. Minor repairs needed___y___.
3. Conditionally safe - major repairs needed_____.
4. Unsafe_____.
5. Reservoir impoundment no longer exists (explain)

   Recommend removal from inspection list_____.

---

13) REMARKS AND RECOMMENDATIONS: (Fully Explain)

Mr. C. E. Wiggin and Mr. Severance of the Northfield School physical plant were present during this inspection.

A considerable amount of brush and small trees have been cut on lower slope. The grade and alignment of dam appears good.

The seepage and or leak noted at toe of slope in area of 6 inch V.C. pipe is completely reversed from what was found 2 years ago, see inspection report dated 11-18-75. At present time a small seepage flow was noted emerging from the ground along the outside of the 6 inch V.C. pipe, while a flow of several G.P.M. was noted emerging from the 6 inch V.C. pipe itself. Origin of this 6 inch pipe is still unknown and so it is difficult to evaluate the seriousness of the existing conditions. A minor amount of fines were noted below the outlet end of the 6 inch pipe.

Another seepage area 30' ± north of the 6 inch V.C. pipe and higher up on the slope was also noted. This area existed at last inspection and does not appear to have increased any in volume of flow. According to proposed plans on file of dam dated October 2, 1933, a concrete core wall exists to within 2 ft. of top of dam. The six inch V.C. pipe is not shown on these plans, nor is a 14 inch C.I. blow-off pipe which outlets just south of the six inch pipe.

It is assumed that the 14 inch blow-off pipe originates in the gatehouse well. Since the well has never been drained, to the memory or knowledge of present school maintenance personnel, it could be that the 6 inch V.C. pipe also originates in the gate well and that the seepage flows or leaks start in that area. It would seem advisable for the owners to check before it creates a serious hazard to safety of dam.

The dam appeared to still be basically sound and safe on day of inspection.

HTS:ma

The Commonwealth of Massachusetts

EXECUTIVE OFFICE OF ENVIRONMENTAL AFFAIRS
DEPARTMENT OF ENVIRONMENTAL QUALITY ENGR.
DIVISION OF WATERWAYS

100 Nashua Street, Boston 02114

June 11, 1976

Mr. Reynold Henry
Northfield School
East Northfield, Massachusetts

RE: Inspection Dam #2-216-217-4
Northfield
Northfield School Upper Main
Reservoir Dam

Dear Sir:

On November 18, 1975 , an Engineer from the Massachusetts Department of Public Works made a visual inspection of the above dam. Our records indicate the owner to be Mt. Hermon School, Northfield. If this information is incorrect will you please notify this office.

The inspection was made in accordance with the provisions of Chapter 253 of the Massachusetts General Laws as amended (Dams-Safety Act). Chapter 706 of the Acts of 1975 transferred the jurisdiction of the so-called "Dams Safety Program" to the Commissioner of the Department of Environmental Quality Engineering.

The results of the inspection indicate that this dam is safe; however the following conditions were noted that require attention:

Remove brush from top and downstream slope.

On northerly end of dike, at toe of slope, a 6" V.C. pipe end was observed. There appears to be considerable flow along the outside of this pipe.

It is recommended that conditions in this area be closely monitored for any changes in characteristics.

We call these conditions to your attention before they become serious and more expensive to correct. With any correspondence please include the number of the Dam as indicated above.

Very truly yours,

David Standley

DAVID STANDLEY
COMMISSIONER

A.Mc:eh

INSPECTION REPORT - DAMS AND RESERVOIRS

1. LOCATION:

~~City~~/Town Northfield. County Franklin. Dam No. 2-6-217-4.

Name of Dam Northfield School Upper "Main" Reservoir Dam.

Topo Sheet No. 13 A. Coordinates: Mass. Rect. N 627,900, E 351,900.

Inspected by: Harold T. Shumway, On Nov. 18, 1975. Date Last Inspection 9-5-73.

---

2. OWNER/S: As of November 18, 1975

per: Assessors____, Reg. of Deeds____, Prev. Insp. X, Per. Contact X.

	Name	St. & No.	City/Town	State	Tel. No.
1.	Northfield, Mt. Hermon School,	Northfield,	Mass.		
2.					
3.					

3. CARETAKER: (if any) e.g. superintendent, plant manager, appointed by absentee owner, appointed by multi owners.

Name	St. & No.	City/Town	State	Tel. No.
Mr. Reynold Henry Director of Physical Plant	Northfield School, East Northfield,	Mass.		413 - 498-5311 Ext. 244

---

4. DATA:

No. of Pictures Taken none. Sketches See description of Dam.

Plans, Where Files of physical plant office on school grounds.

---

5. DEGREE OF HAZARD: (if dam should fail completely)*

1. Minor____. 3. Severe X.

2. Moderate____. 4. Disastrous____.

Comments: 31 million gallons impoundment - could affect streets and homes downstream a short distance.

*This rating may change as land use changes (future development).

(6.) OUTLETS: OUTLET CONTROLS AND DRAWDOWN

No. 1 Location and Type: South end of dam - spillway - 30'W. x 4'H. x 134'L. conc. and stone masonry side chute.

Controls yes, TYPE: 3" x 2'-8" x 30' flashboards.

Automatic ____. Manual X. Operative Yes X, No ____.

Comments: 1" dia. I.P. stanchions for flashboards designed to fail at certain pressures.

No. 2 Location and Type: Approx. center of dam - Gate well intake structure.

Controls yes, Type: Intake - 2 ea. 14" dia. C.I. pipes - outlet pipes - 1 ea. 14"dia C.I. water main - 1 ea. 14" pipe blow-off, all pipes equipped with gate valves.

Automatic ____. Manual X. Operative Yes X, No ____.

Comments: 14" dia. C.I. blow-off pipe not shown on proposed plans of dam.

No. 3 Location and Type: ____.

Controls ____, Type: ____.

Automatic ____. Manual ____. Operative Yes ____, No ____.

Comments: ____.

Drawdown present Yes X, No ____. Operative Yes X, No ____.
Comments: Per word of Maintenance Supervisor.

(7.) DAM UPSTREAM FACE: Slope 2 1/2:1, Depth Water at Dam 2'-8" to top flashboards.

Material: Turf X. Brush & Trees ____. Rock fill ____. Masonry ____. Wood ____.

Other 12" stone paving bedded in gravel.

Condition: 1. Good X. 3. Major Repairs ____.

2. Minor Repairs ____. 4. Urgent Repairs ____.

Comments: Heavy growth of weeds, should be cut off to prevent brush growth.

(8.) DAM DOWNSTREAM FACE: Slope 2:1.

Material: Turf X. Brush & Trees X. Rock Fill ____. Conc. & stone Masonry X (Spillway). Wood ____.

Other ____.

Condition: 1. Good ____. 3. Major Repairs X.

2. Minor Repairs ____. 4. Urgent Repairs ____.

Comments: Heavy flow of water along outside of a 6" dia. V.C. pipe at toe of slope - origin unknown - see remarks.

(9.) EMERGENCY SPILLWAY: Available yes. Needed ____.

Height Above Normal Water unknown Ft. - Flashboards 2'-8" H. at entrance.

Width 30 Ft. Height 4 Ft. Material conc. walls - conc. & stone paved floor.

Condition: 1. Good ____. 3. Major Repairs ____.

2. Minor Repairs X. 4. Urgent Repairs ____.

Comments: Some weed and grass growth in small crevices in stone paved floor of spillway.

(10.) WATER LEVEL AT TIME OF INSPECTION: 1 1/3 Ft. Above ____. Below X.

Top Dam X F.L. Principal Spillway ____.

Other ____.

Normal Freeboard 1'-4" Ft. with flashboards in place.

(11.) SUMMARY OF DEFICIENCIES NOTED:

Growth (Trees and Brush) on Embankment yes - lower part of downstream slope heavily wooded.

Animal Burrows and Washouts None found.

Damage to Slopes or Top of Dam See erosion below.

Cracked or Damaged Masonry some grouting missing in paved floor of spillway yes - minor cracks in conc. side walls.

Evidence of Seepage yes - on southerly end of toe of slope and on northerly end.

Evidence of Piping Questionable - see remarks.

Leaks yes - see item #8 and remarks.

Erosion yes - minor erosion on northerly end of dike on downstream slope.

Trash and/or Debris Impeding Flow None found.

Clogged or Blocked Spillway 2'-8" height of flashboards in place.

Other ____.

(12.) OVERALL CONDITION:

1. Safe_____.
2. Minor repairs needed X
3. Conditionally safe - major repairs needed_____.
4. Unsafe_____.
5. Reservoir impoundment no longer exists (explain)

   Recommend removal from inspection list_____.

(13.) REMARKS AND RECOMMENDATIONS: (Fully Explain)

Alignment and grade of this embankment type dam appear good. Upstream slope appears stable. A year's growth of weeds and wild grasses was noted on top and downstream slope. Lower elevations of downstream slope is heavily wooded with fir trees and brush. At approx. tree line on southerly end of embankment some seepage was noted. There was also minor seepage noted on northerly end of dike at toe of first slope.

Flashboards were in place on side chute spillway intake to a height of 2'-8". Water was overflowing these flashboards 1" ± in depth at time of inspection. Some minor spalling of grouting in spillway floor downstream of flashboards was noted and a minor weed growth was noted in crevices.

On the northerly end of dike at toe of slope near outlet end of 14" C.I. blow-off pipe a 6 inc V.C. pipe end was observed. A small flow of water was emerging from this pipe but a much larger flow of red oxide stained water was flowing along northerly side and outside of this 6 inc pipe. Origin and purpose of this pipe was unknown by Mr. Reynold Henry, Physical Plant Director, and two other maintenance employees who were present during this inspection. One of t employees, who has apparently worked for the school for many years, stated that there had bee a flow of water in this area for years. He also stated that flow seemed to be greater in volume than usual.

This flow of water, coupled with a very wet, soft ground, seepage area on the slope direct above and approx. 10' to 15' higher up the slope would appear to indicate a large leak or possit a piping condition. There did not appear to be any accumulation of fines in outlet area of this water flow but invert of six inch V.C. pipe was 1/3 full of silt.

This condition was discussed with Mr. Henry who stated he would keep a close check on this flow for any further enlargement in volume.

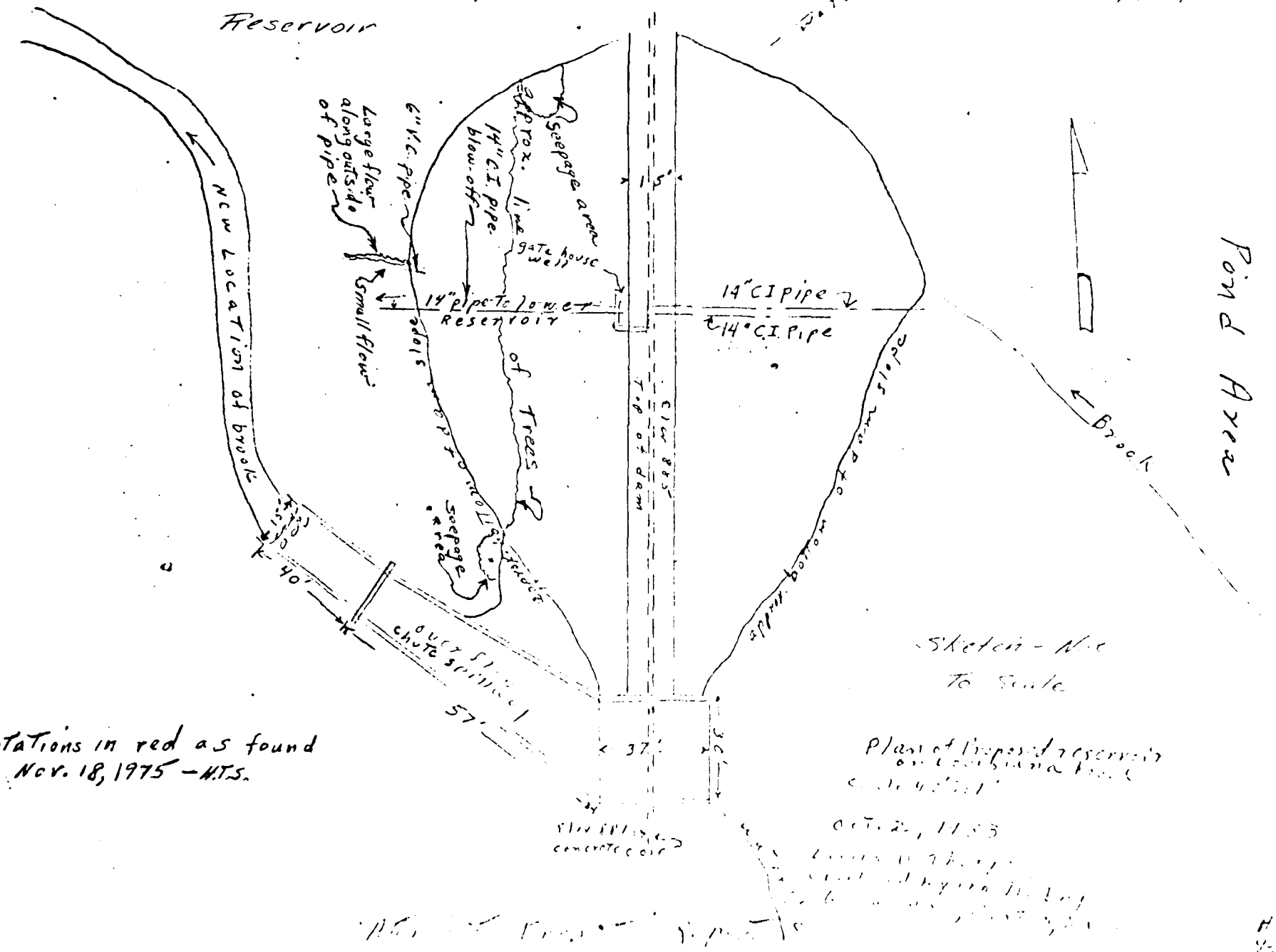
The District is rating this dam as safe, minor repairs needed, but recommends that owner be advised to establish origin of 6 inch V.C. pipe if possible and to closely monitor the flow of water along outside of this pipe for any changes. Enclosed sketches show approx. location of seepage areas and 6" V.C. pipe.

UTC AL

Sheet 1 of 4 sheets

Reservoir

Northfield School Upper "Main" Reservoir



Sketch - Not to Scale

Notations in red as found on Nov. 18, 1975 - H.T.S.

Plan of Proposed Reservoir

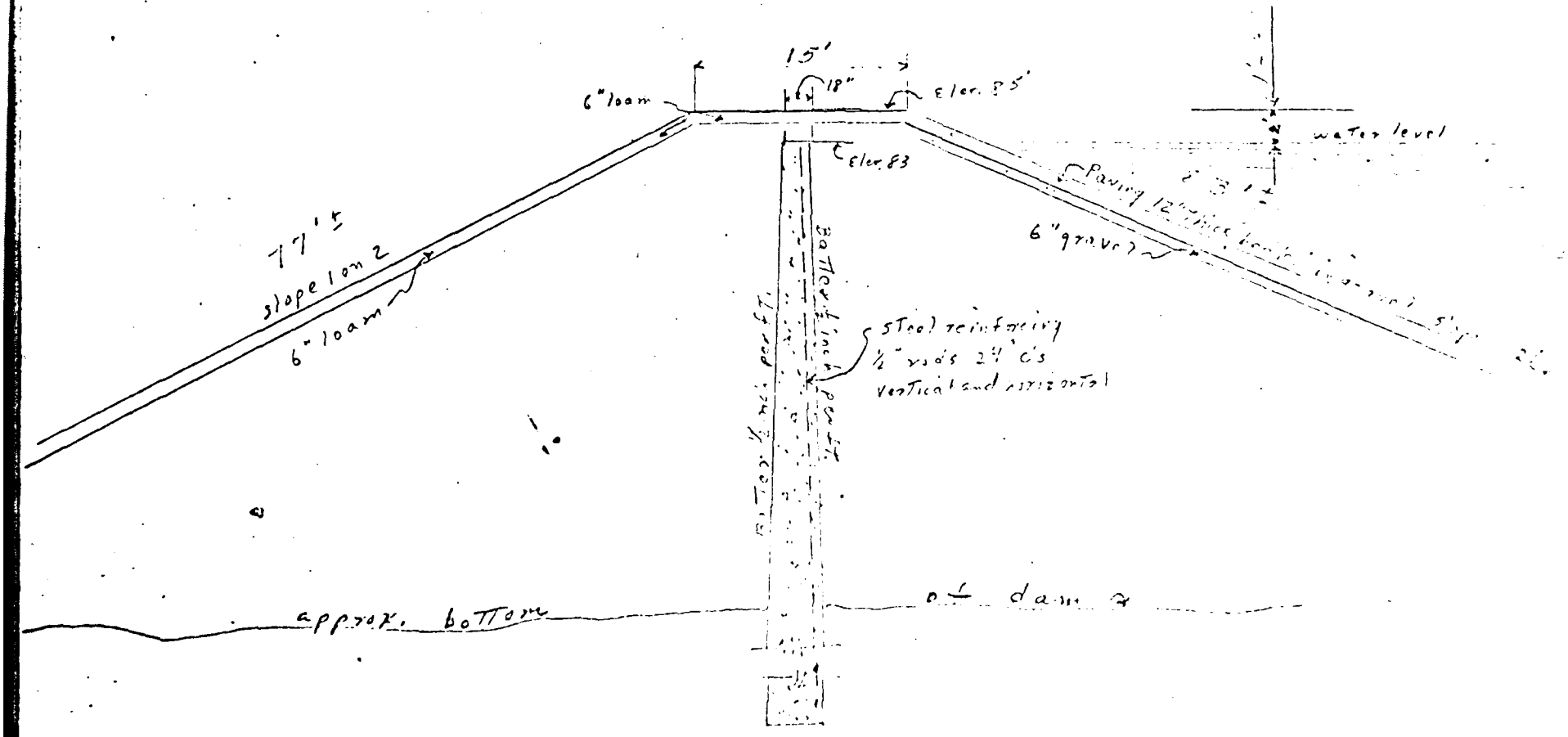
Oct. 2, 1953

H.T.S. 9-5-1

B-14

Sheet 2 of 4 sheets

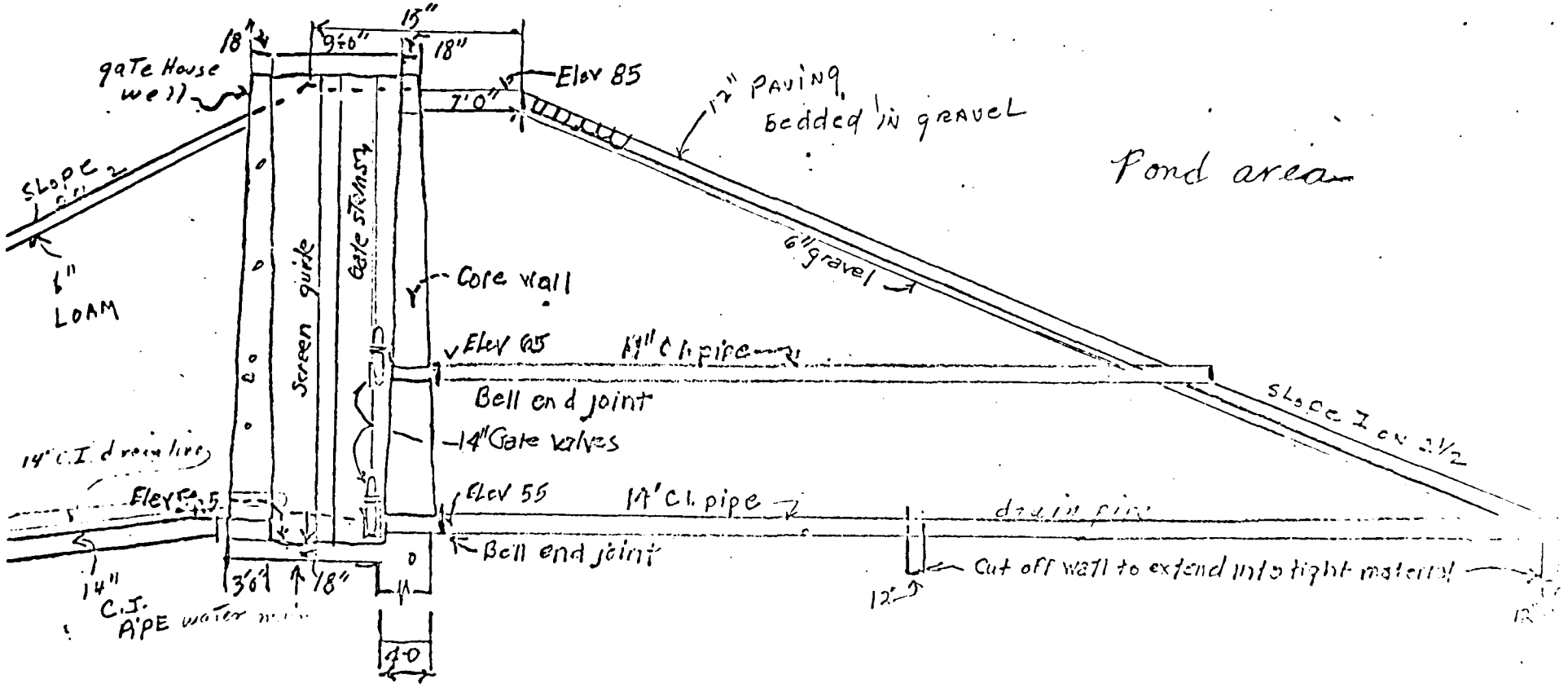
Section Through Dam



Note
copied from plans
on file at school
maintenance office

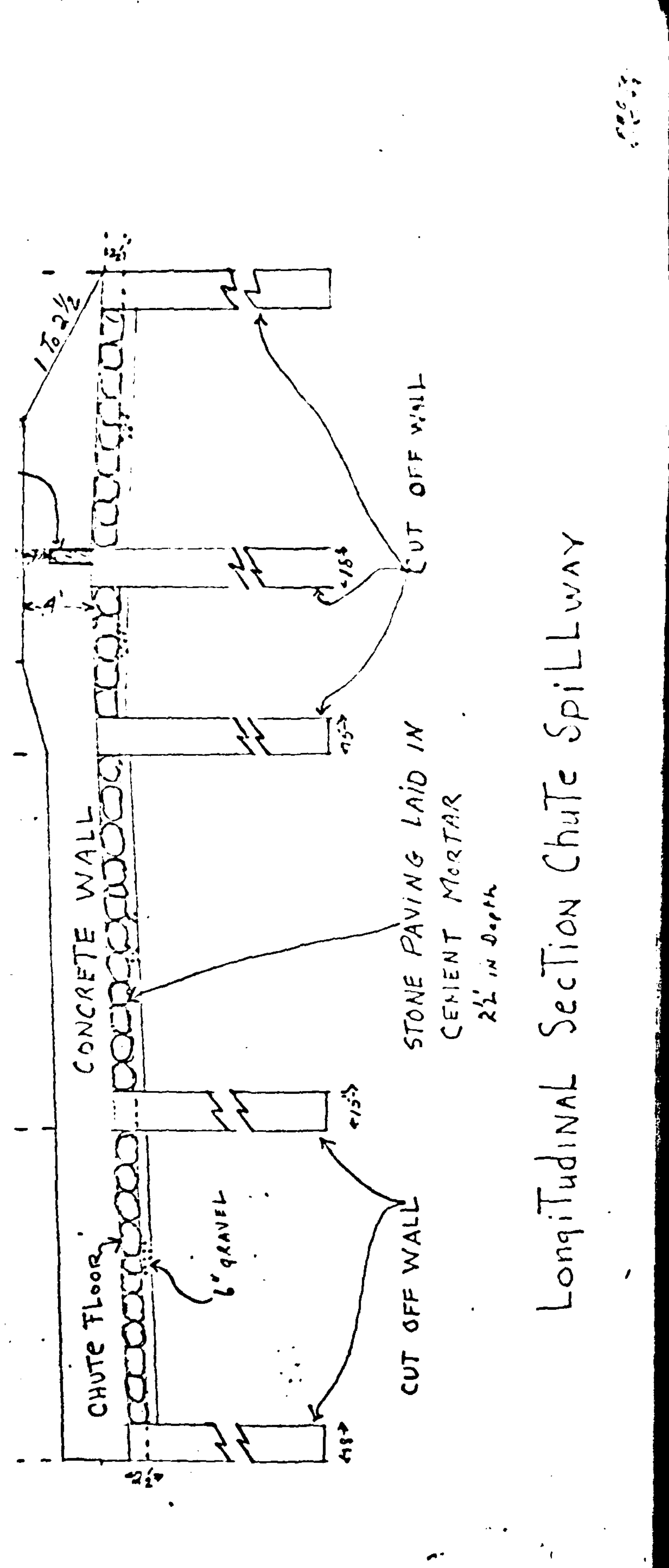
Dam # 2-6-217-4

Sections Through DAM + Gate House



B-16

Section through Dam at Gate House



NORTHFIEL
EAST NORTHFIELD

OFFICE OF THE DIRECTOR
OF PHYSICAL PLANT

The Commonwealth of Massachuse
Department of Public Works
Office of the Commissioner
100 Nashua Street
Boston, Massachusetts

Attention: Mr. Bruce Campbell

Dear Mr. Campbell:

Thank you for your r
to "All Owners Or Caretakers C
the Louisana Brook located in
capacity of the Reservoir is 3
voir supplies water for the No
also to the Town of East North
in paragraph 3 of your notice
and other obstructions should

It would not be prac
boards from our Reservoir spil
an essential part of the Rese
remove the flashboards, we wo
capacity of our Reservoir. O
supports so designed that the
off period. Our spillway is
flashboards, of course, run t
have always operated with the
ask you to reconsider your re
have the facility, however, o

Mr. Bruce Campbell
Commissioner

valve, which would increase the outflow from our main Reservoir and consequently cause the dam to overflow in a small intake Reservoir below the main Reservoir. This should be able to relieve pressure as water tables continue to rise. I can understand and appreciate your concern in this regard, however, if we are to operate our Reservoir properly, I feel compelled to give you the above information.

Sir, will you please reply to this communication?

Sincerely,

C. A. Pelzel

Carl A. Pelzel
Director of Physical Plant

CP/g

December 12, 1972

Mr. Carl A. Pelzel
Director of Physical Plant
Northfield School
East Northfield, Massachusetts

RE: Dam #2-6-217-4
Northfield
Northfield Schools Upper
Reservoir Dam

Dear Mr. Pelzel:

Your letter dated December 4, 1972, to Commissioner Campbell, has been referred to the Division of Waterways.

The Commissioners "Notice to Owners or Caretakers of Dams" is intended only as an alert to responsible parties. The design of the flashboards, as described in your letter apparently has the "built-in" safety factor of failure when predetermined stresses exist. Other safety features such as valves, trash racks, etc. apparently have been checked and found operable, thus satisfying the intent of the notice.

If this office may be of further assistance, please do not hesitate to contact us.

Very truly yours,

Fred. C. Schwelm

FRED. C. SCHWELM, P.E.
Deputy Chief Engineer

LRA:hlb
cc:F.J.Hoey
R. Salls

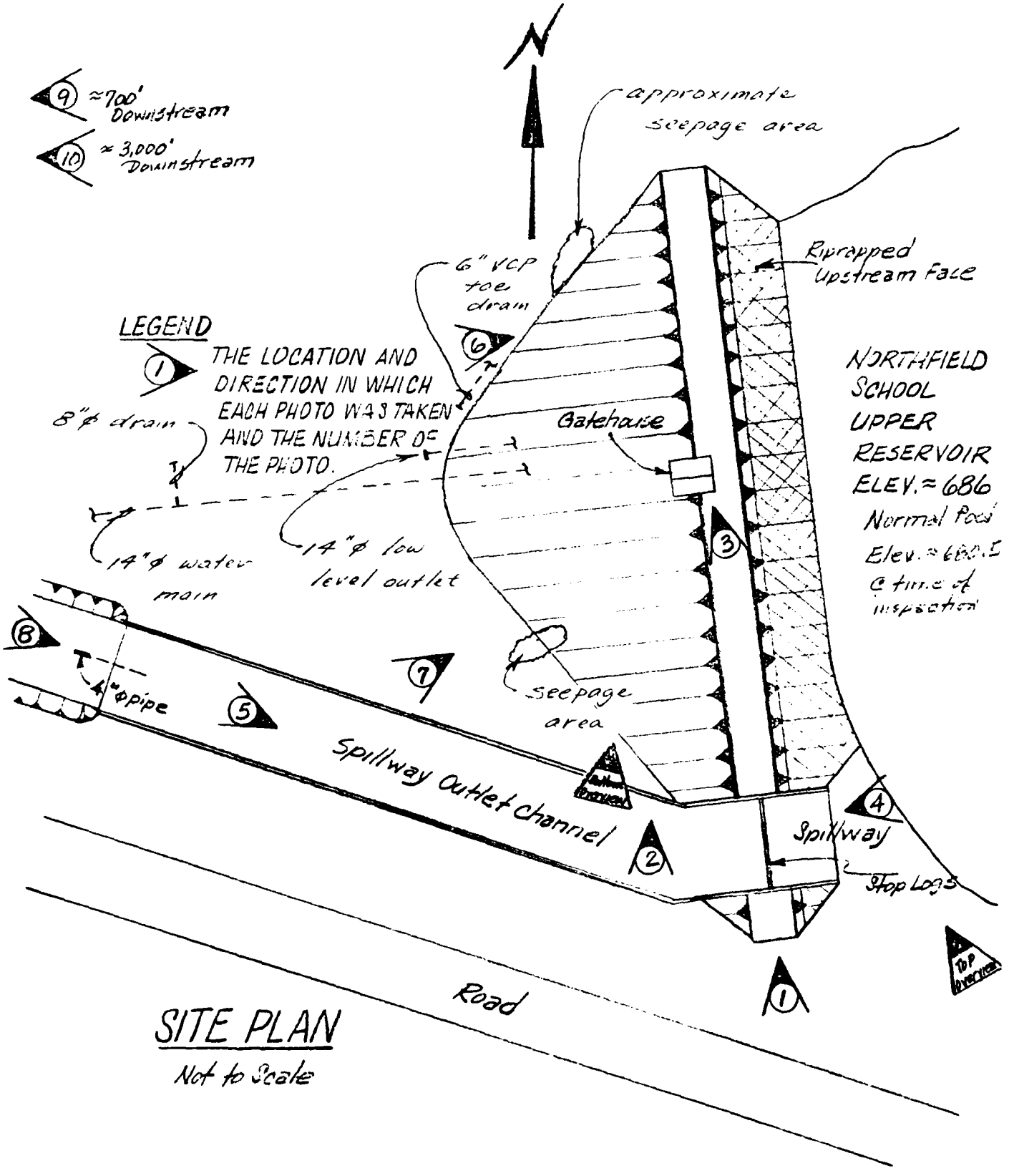
APPENDIX C

PHOTOGRAPHS

APPENDIX C
SELECTED PHOTOGRAPHS OF PROJECT

O'BRIEN & GERE
ENGINEERS, INC

Northfield School Upper Reservoir Dam	A	#	1/27/81	2060-002



1. VIEW ALONG CENTERLINE OF DAM FROM THE SOUTH ABUTMENT. (12/4/80)

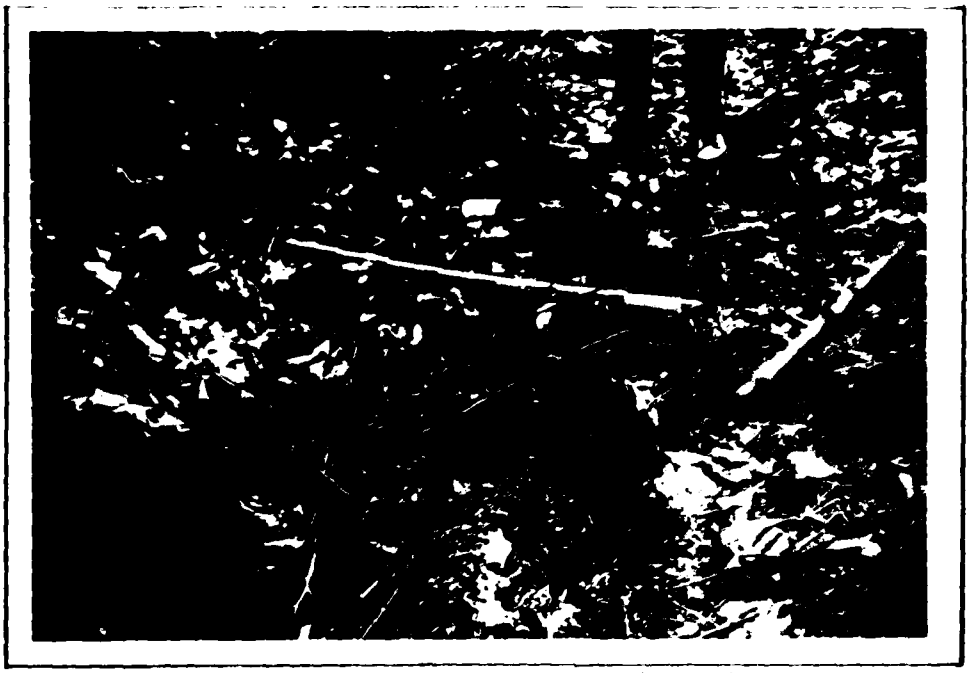
2. DOWNSTREAM FACE OF DAM SHOWING TREE AND BRUSH COVER. (12/4/80)

3. GATEHOUSE ON CREST OF DAM.

4. SPILLWAY INLET CHANNEL AND SPILLWAY.

5. SPILLWAY OUTLET CHANNEL AND SPILLWAY LOOKING UPSTREAM. (12/4/80)

6. SEEPAGE AT DOWNSTREAM TOE OF THE DAM. (12/4/80)



7. SEEPAGE AT DOWNSTREAM TOE OF THE DAM. (12/4/80)

8. 4-INCH PIPE DOWNSTREAM OF THE SPILLWAY OUTLET CHANNEL. (12/4/80)

9. HOLDING POND ABOUT 700 FEET DOWNSTREAM FROM THE DAM. (12/4/80)

10. POTENTIAL DAMAGE AREA APPROXIMATELY 3000 FEET (12/4/80)
DOWNSTREAM FROM THE DAM.

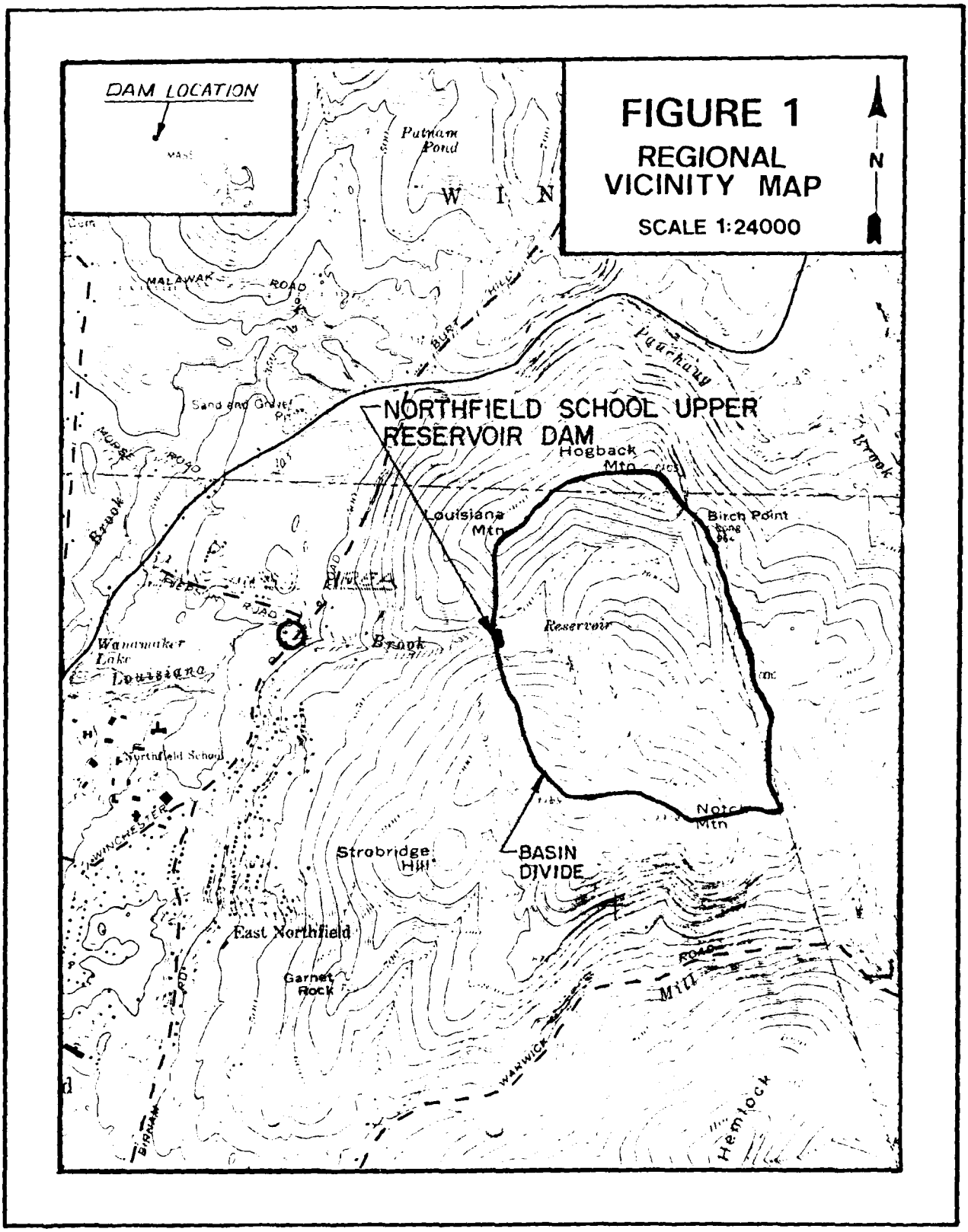
APPENDIX D

HYDROLOGIC AND HYDRAULIC ENGINEERING DATA

APPENDIX D

HYDROLOGIC AND HYDRAULIC COMPUTATIONS

TABLE OF CONTENTS


DAM LOCATION
FIGURE 1
REGIONAL
VICINITY MAP
SCALE 1:24000
N
NORTHFIELD SCHOOL UPPER
RESERVOIR DAM
Putnam
Pond
W I N
MALAWAK
ROAD
Parkway
Sand and Gravel
Pit
Hogback
Mtn
Louisiana
Mtn
Birch Point
Reservoir
Brook
Wanamaker
Lake
Louisiana
Northfield School
WINCHESTER
Strobridge
Hill
BASIN
DIVIDE
East Northfield
Garnet
Rock
Mill
ROAD
WARWICK
Hemlock

O'BRIEN & GERE

SUBJECT	SHEET	BY	DATE	JOB NO.
Grandin Reservoir Dam	D-2	ADH	1/09/61	2060.002
(North Field School Upper Reservoir Dam)	1 of 4		2/23/61	

(I.) Drainage Area : 0.6 sq. mi.

(II.) Snyder Hydrograph Coefficients

- $C_T = 2.0$ & $C_p = 0.6$

(III.) T_p Calculation

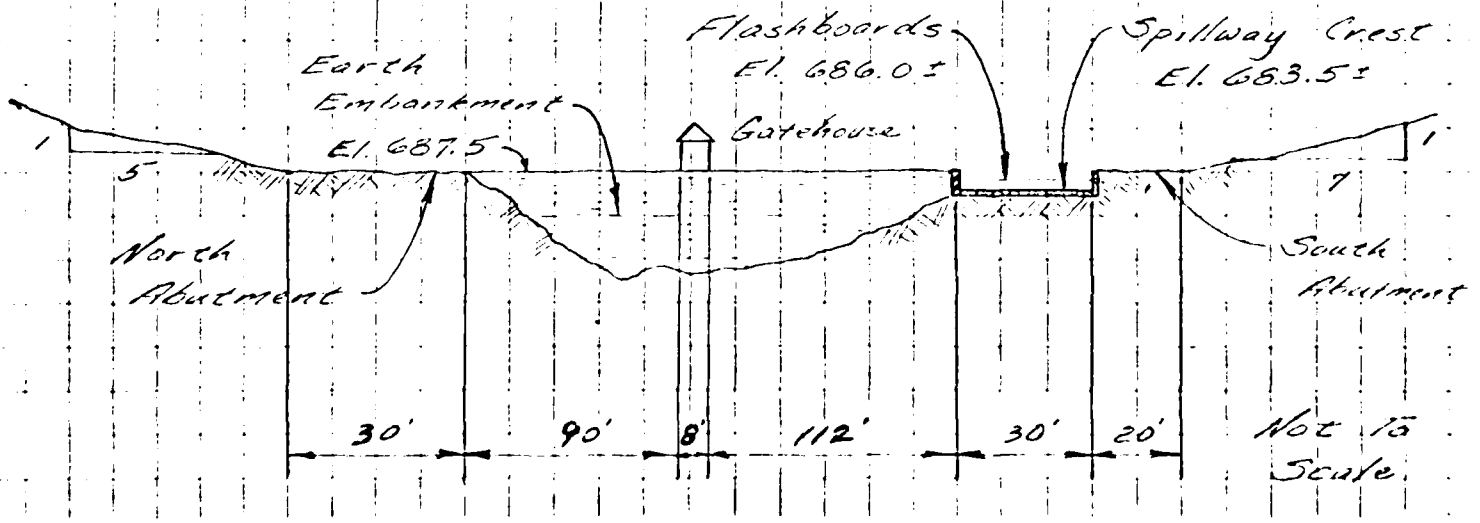
$$T_p = C_T (L \times L_{ca})^{0.3}$$

- where L = main channel length from the outflow point to the upstream watershed boundary (river miles)

and L_{ca} = main channel length from the outflow point to a point opposite the center of the river basin. (river miles)

$$T_p = (2.0)(1.5 \times 0.85)^{0.3} = 2.15 \Rightarrow \text{say } \underline{2.25 \text{ Hours}}$$

(IV.) Sketch : Dam Elevation & Spillway Dimensions



O'BRIEN & GERE

SUBJECT	SHEET	BY	DATE	JOB NO
Grandin Reservoir Dam	D-3	ADH	1/14/81	2060.002

(Northfield School Upper Reservoir Dam) VB 2/26/81

(V.) Stage - Discharge Table *

Elevation (NGVD)	H_1 (ft)	Q_1 (cfs)	H_2 (ft)	Q_2 (cfs)	H_3 (ft)	Q_3 (cfs)	ΣQ (cfs)
686	0	0	—	—	35.5	20	20
687	1.0	99	—	—	36.5	21	120
687.5	1.5	182	0	0	37	21	203
688	2.0	280	0.5	234	37.5	21	535
689	3.0	514	1.5	1,247	38.5	21	1,782
690	4.0	792	2.5	2,744	39.5	22	3,558

Where Q_1 = Discharge over spillway

($Q = CLH^{3/2}$; $C = 3.3$ for 30' wide sharp-crested weir; free discharge over weir.)

Q_2 = Flow over dam crest

($Q = CLH^{3/2}$; $C = 2.6$ for broad-crested weir; side slopes 5H:1V & 7H:1V)

Q_3 = Discharge through 4"-inch drain

($Q = 1.318\, C_{hw}\, A\, R^{0.63}\, S^{0.54}$ (Hazen-Williams); C_{hw} assumed to be 95; head loss computed with effective length of 271 feet)

* The stage-discharge relationship was developed assuming that the flashboards will remain in place for the duration of the overtopping period.

O'BRIEN & GERE

SUBJECT	SHEET	BY	DATE	JOB NO.
Grandin Reservoir Dam	D-4	ADH	1/15/81	2060.002

(Northfield Saisbl Upper Reservoir Dam) JH 2/25/81

(VI.) Stage - Storage Table *

Description	Elevation (MSL)	Area (acres)	Storage (acre-feet)
Toe of Dam	656.5±	0	0
Spillway Crest	686.±	7.5	91
Top of Dam	687.5±	8.8	104
Test Flood El.	688.0±	9.4	109

* Areas have been estimated from the "Northfield, Mass.-NH-VT." USGS map. Storage data have been computed according to the conical method by the HEC-1-DB computer program.

(VII.) PMP Data (Drainage Area ≈ 0.6 mi²)

24-Hr. 200 mi² probable maximum precipitation:

= 20.2 inches (Ref.: HMS #33)

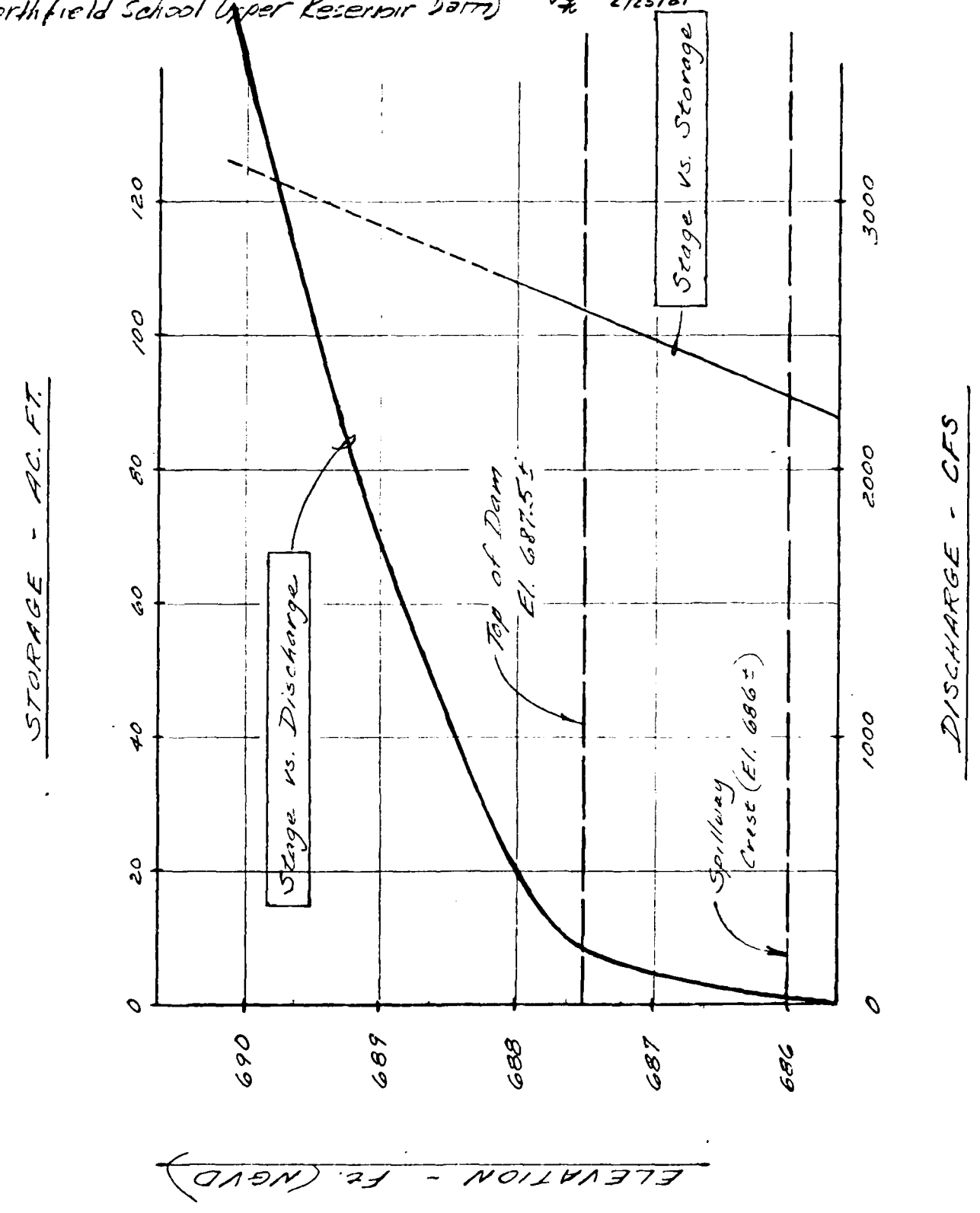
Also,

6-Hr. % of index for this basin	≈	111
12-Hr. " " " " " "	≈	123
24-Hr. " " " " " "		132

O'BRIEN & GERE
ENGINEERS, INC

SUBJECT	SHEET	BY	DATE	JOB NO
Grandin Reservoir Dam	D-5	ADH	1/12/81	2060.002

(Northfield School Upper Reservoir Dam) ✓# 2/25/81



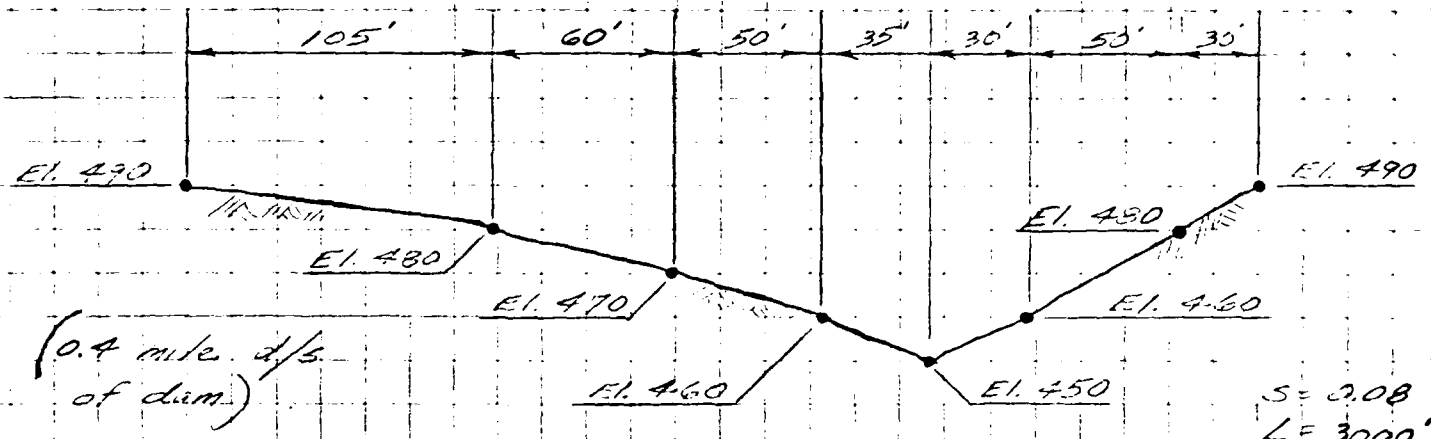
O'BRIEN & GERE

SUBJECT	SHEET	BY	DATE	JOB NO
Grandin Reservoir Dam	D-6	ADH	1/15/81	2060.002

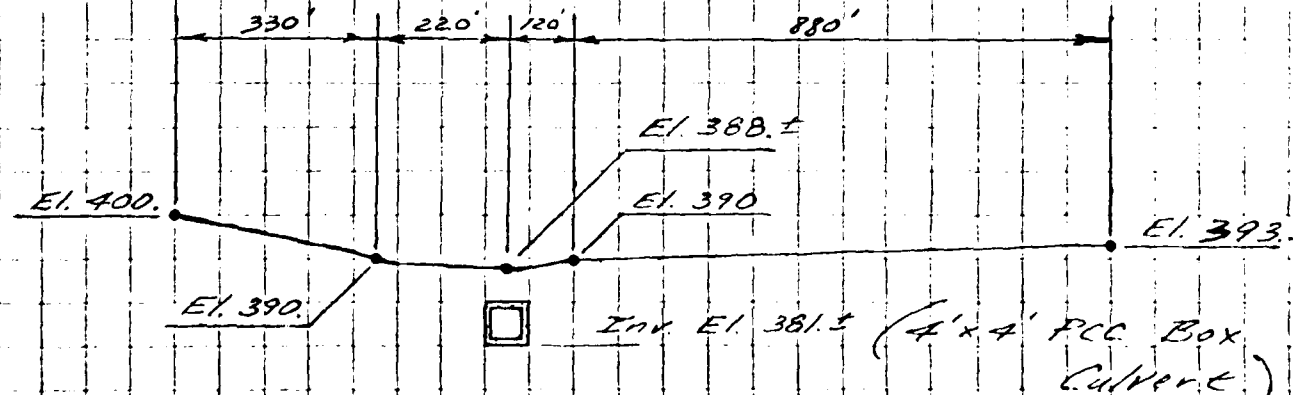
(Merrimack Old School Upper Reservoir Dam) "A" 2/25/81

(VIII.) Downstream Routing Information

The breach analysis for Grandin Reservoir Dam included routing the flow along Louisiana Brook for a distance of approximately 0.6 mile to the hazard area. A stage-discharge relationship was determined for routing flow through a 4'x4' box culvert and over Winchester Road at the hazard area. The following cross sections were used in the routing procedure:



Section: Upper Reach of Louisiana Brook
(Not To Scale)



Section @ Winchester Road
(Not To Scale)

O'BRIEN & GERE

SUBJECT	SHEET	BY	DATE	JOB NO
Grandin Reservoir Dam (Northfield School/Upper Reservoir Dam)	D-7	AEH	1/15/81	2060.002

(VIII.) Downstream Routing Information (cont.)

The following stage-discharge table was compiled, based upon the section at Winchester Road illustrated on p. D-6 of this Appendix. Flow through the culvert was calculated through the use of the orifice equation* ($Q = Ca\sqrt{2gh}$), where $C = 0.79$. Flow over the road was calculated through the use of the weir flow equation ($Q = CLH^{3/2}$), where $C = 2.7$ for the paved broad-crested weir.

Stage - Discharge Table: (Section @ Winchester Road)

Elevation (NGVD)	H_1 (ft)	Q_1 (cfs)	H_2 (ft)	Q_2 (cfs)	ΣQ (cfs)
381	0	0	—	—	0
382	1	22	—	—	22
383	2	58	—	—	58
384	3	99	—	—	99
385	4	117	—	—	117
386	5	143	—	—	143
387	6	176	—	—	176
389	8	227	1	162	389
390	9	249	2	918	1,167
391	10	268	3	3,090	3,358
392	11	336	4	9,029	9,365

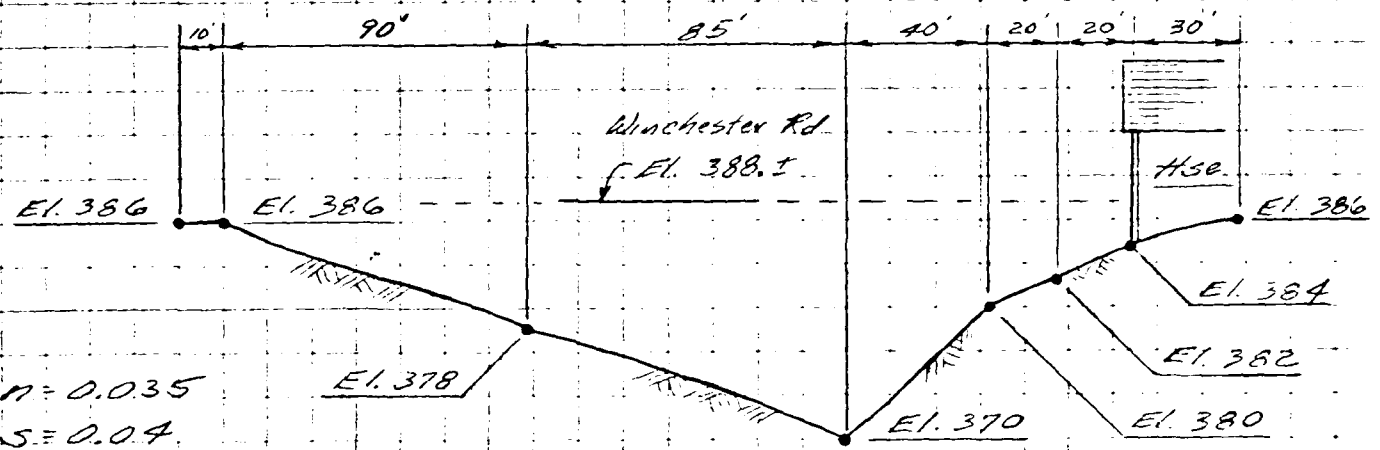
* Note that Mannings Equation was used for open channel flow. ($n \simeq .025$, $s \simeq .025$)

O'BRIEN & GERE

SUBJECT	SHEET	BY	DATE	JOB NO
Grandin Reservoir Dam (Northfield Pond/Upper Reservoir Dam)	D-8	ADH	1/19/81	2060.002

(VIII.) Downstream Routing Information (cont.)

The foregoing stage-discharge relationship was developed, assuming that there was free discharge downstream of Winchester Road. The following cross section, taken from inspection of the USGS map, supports that assumption since it is sloped at roughly 4 percent.



(~150' d/s of Winchester Road)

Channel Section @ D/s Hazard Area

(Not To Scale) (Looking Upstream)

Stage - Storage Table: (just u/s of Winchester Rd.)

Description	Elev (NGVD)	Area (Ac.)	Storage (Ac Ft)
Culvert Invert	381.±	0	0
Crest of Road	388.±	0.4	1
Test Flood	390.3±	1.2	2
"400" Contour	400.±	4.8	27

```
1*********************************
  FLOOD HYDROGRAPH PACKAGE (HEC-1)
  DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  01 APR 80
**********************************
   1          A1         HYDROLOGIC ANALYSIS OF GRANDIN RESERVOIR DAM
   2          A2            NATIONAL DAM INSPECTION PROGRAM
   3          A3         NEW ENGLAND DIVISION   CORPS OF ENGINEERS
   4          B     300      0     15      0      0      0      0      0      4      0
   5          B1      5
   6          J       1      8      1
   7          J1    .05     .1    .15     .2    .25     .5    .75    1.0
   8          K       0  INGRD                                  1
   9          K1                INFLOW TO GRANDIN RESERVOIR                    1
  10          M       1      1    0.6
  11          P       0   20.2    111    123    132
                                                             0    0.5
  12          T
  13          W    2.25    0.6
  14          X     1.7    -.1      2
  15          K       1  GRDOUT                                 1
  16          K1                ROUTED OUTFLOW FROM GRANDIN RESERVOIR
  17          Y                        1      1
  18          Y1      1                                          -686     -1
  19          Y4    686    687  687.5    688    689    690
  20          Y5      0    170    203    535   1282   3558
  21          $A      0    8.3   10.7
  22          $E    253    686    695
  23          $$    686
  24          $D  687.5
  25          K      99

             PREVIEW OF SEQUENCE OF STREAM NETWORK CALCULATIONS

                  RUNOFF HYDROGRAPH AT         INGRD
                  ROUTE HYDROGRAPH TO          GRDOUT
                  END OF NETWORK

1*********************************
  FLOOD HYDROGRAPH PACKAGE (HEC-1)
  DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  01 APR 80
**********************************

RUN  DATE* 81/01/22.
     TIME* 08.48.51.

                HYDROLOGIC ANALYSIS OF GRANDIN RESERVOIR DAM
                   NATIONAL DAM INSPECTION PROGRAM
                NEW ENGLAND DIVISION   CORPS OF ENGINEERS

                               JOB SPECIFICATION
     NQ     NHR    NMIN    IDAY     IHR    IMIN   METRC    IPLT    IPRT   NSTAN
[illegible] [illegible] [illegible] [illegible]  0       0       0       0       4       0
                          JOPER     NWT   LROPT   TRACE
                    [illegible]       0       0       0

                   MULTI-PLAN ANALYSES TO BE PERFORMED
                     NPLAN= 1 NRTIO= 8 LRTIO= 1
     RTIOS= [illegible]  .10   .15   .20   .25   .50   .75  1.00
```

********** ********** ********** ********** **********

SUB AREA RUNOFF COMPUTATION

INFLOW TO GRANDIN RESERVOIR

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
INGRD	0	0	0	0	0	1	0	0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	1	.60	0.00	.60	0.00	0.000	0	1	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.00	20.20	111.00	123.00	132.00	0.00	0.00	0.00

TRSPC COMPUTED BY THE PROGRAM IS .800

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0	0.00	0.00	1.00	0.00	0.00	1.00	0.00	.50	0.00	0.00

UNIT HYDROGRAPH DATA

TP= 2.25 CP= .60 NTA= 0

RECESSION DATA

STRTQ 1.20 QRCSN= .10 RTIOR= 2.00

UNIT HYDROGRAPH 53 END OF PERIOD ORDINATES, LAG= 2.25 HOURS, CP= .61 VOL= 1.00

4.	11.	28.	44.	62.	79.	92.	101.	106.	105.
97.	86.	77.	69.	62.	56.	49.	44.	40.	35.
32.	28.	25.	23.	20.	18.	16.	14.	13.	12.
10.	9.	8.	7.	7.	6.	5.	5.	4.	4.
3.	3.	3.	2.	2.	2.	2.	2.	1.	1.
1.	1.	1.							

0

END OF PERIOD FLOW

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q

SUM 21.33 14.94 6.39 23329.

(542.)(379.)(162.)(661.93)

********** ********** ********** ********** **********

HYDROGRAPH ROUTING

ROUTED OUTFLOW FROM GRANDEN RESERVOIR

ISTAO	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
GRDOUT	1	0	0	0	1	0	0	

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	1	0	0	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	-686.	1

STAGE	686.00	687.00	687.50	688.00	689.00	690.00
FLOW	0.00	120.00	203.00	535.00	1702.00	3558.00
SURFACE AREA=	0.	8.	11.			
CAPACITY=	0.	91.	177.			
ELEVATION=	653.	686.	695.			

CREL	SPWID	COOW	EXPW	ELEVL	COOL	CAREA	EXPL
686.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

DAM DATA

TOPEL	COOD	EXPD	DAMWID
687.5	0.0	0.0	0.

PEAK OUTFLOW IS 49. AT TIME 18.75 HOURS

PEAK OUTFLOW IS 99. AT TIME 18.75 HOURS

PEAK OUTFLOW IS 152. AT TIME 18.50 HOURS

PEAK OUTFLOW IS 206. AT TIME 18.50 HOURS

PEAK OUTFLOW IS 272. AT TIME 18.00 HOURS

PEAK OUTFLOW IS 548. AT TIME 18.00 HOURS

PEAK OUTFLOW IS 829. AT TIME 18.00 HOURS

PEAK OUTFLOW IS 1094. AT TIME 18.00 HOURS

1 ********** ********** ********** ********** **********

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIO 1	RATIO 2	RATIO 3	RATIO 4	RATIO 5	RATIO 6	RATIO 7	RATIO 8
				RATIOS APPLIED TO FLOWS							
				.05	.10	.15	.20	.25	.50	.75	1.00
HYDROGRAPH AT	INGRD	.60	1	55.	109.	164.	219.	273.	546.	820.	1094.
	(	1.55)	(	1.55)(	3.09)(	4.64)(	6.19)(	7.74)(	15.47)(	23.21)(	30.94)(
ROUTED TO	GRDOUT	.60	1	49.	99.	152.	206.	272.	549.	820.	1094.
	(	1.55)	(	1.40)(	2.79)(	4.30)(	5.84)(	7.70)(	15.55)(	23.22)(	30.99)(

1 SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	686.00	686.00	687.50
STORAGE	91.	91.	104.
OUTFLOW	0.	0.	203.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.05	686.41	0.00	95.	49.	0.00	18.25	0.00
.10	686.82	0.00	98.	99.	0.00	18.25	0.00
.15	687.19	0.00	101.	152.	0.00	18.50	0.00
.20	687.50	.00	104.	206.	.25	18.50	0.00
.25	687.60	.10	105.	272.	2.25	18.00	0.00
.50	688.01	.51	108.	548.	5.00	18.00	0.00
.75	688.23	.73	110.	820.	6.75	18.00	0.00
1.00	688.45	.95	112.	1094.	8.00	18.00	0.00

```
1**********
 FLOOD HYDROGRAPH PACKAGE (HEC-1)
 DAM SAFETY VERSION      JULY 1978
   LAST MODIFICATION  01 APR 80
 **********
      1                A1          HYDROLOGIC ANALYSIS OF GRANDIN RESERVOIR DAM BREACH
      2                A2                    NATIONAL DAM INSPECTION PROGRAM
      3                A3          NEW ENGLAND DIVISION -- CORPS OF ENGINEERS
      4                B    200       0       10        0        0        0        0        0       -4        0
      5                B1     5
      6                J      2       1        1
      7                J1   .21     .21
      8                K      0   INGRD                                                    1
      9                K1                  INFLOW TO GRANDIN RESERVOIR DAM
     10                M      1       1      0.6                 0                                         1
     11                P      0    20.2      111      123      132
     12                T                                                                   0      .05
     13                W   2.25     0.6
     14                X   -1.7     -.1        2
     15                K      1   GROUT                                                    1
     16                K1                  ROUTED OUTFLOW FROM GRANDIN RESERVOIR
     17                Y                                    1        1
     18                Y1     1                                                      -686.      -1
     19                Y4   686     687    687.5      688      689      690
     20                Y5     0     120      203      535     1782     3558
     21                $A     0     7.5      9.8
     22                $E   653     686      690
     23                $$   636
     24                $D 687.5
     25                $B    60    0.01      656      1.5      686    687.5
     26                $B    60    0.01      656      1.5      686      690
     27                K      1   LB=1                                                     1
     28                K1                  CHANNEL ROUTING TO WINCHESTER ROAD
     29                Y                                    1        1
     30                Y1     1                                                       -1
     31                Y6   .06     .04      .06      450      490     3000      .08
     32                Y7     0     490      105      480      165      470      215      460      250      450
     33                Y7   250     460      330      480      360      490
     34                K      1   WINRD                                                    1
     35                K1                  ROUTED OUTFLOW AT WINCHESTER ROAD
     36                Y                                    1        1
     37                Y1     1                                                   -381.1       -1
     38                Y4   381     382      383      384      385      386      387      388      389      390
     39                Y4   391
     40                Y5     0      22      58.       99      117      143      176      203      389     1167
     41                Y5  3358
     42                $A     0     0.4      4.8
     43                $E   381     390      400
     44                $$ 381.1
     45                $D   388
     46                K      1   HAZARD                                                   1
     47                K1                  CHANNEL ROUTING TO HAZARD CENTER
     48                Y                                    1        1                       1
     49                Y1     1
     50                Y6  0.06    0.04     0.05      370      386      150      .04
     51                Y7     0     386       10      295      190      370      195      370      225      390
     52                Y7   245     382      265      384      225      386
     53                K     99
1                    REVIEW OF SEQUENCE OF STREAM NETWORK CALCULATIONS

                                  INCREMENTAL HYDROGRAPH AT        ENGRD
                                  ROUTE HYDROGRAPH TO              SCOUT
                                  ROUTE HYDROGRAPH TO              LB 1
                                  ROUTE HYDROGRAPH TO              WINRD
                                  ROUTE HYDROGRAPH TO              HAZARD
                                  END OF NETWORK
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DAM SAFETY VERSION JULY 1978
LAST MODIFICATION 01 APR 80
****

RUN DATE= 81/02/24.
TIME= 06.03.40.

HYDROLOGIC ANALYSIS OF GRANDIN RESERVOIR DAM BREACH
NATIONAL DAM INSPECTION PROGRAM
NEW ENGLAND DIVISION - CORPS OF ENGINEERS

JOB SPECIFICATION

NQ	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
200	0	10	0	0	0	0	0	-4	0

JOPER	NWT	LROPT	TRACE
5	0	0	0

MULTI-PLAN ANALYSES TO BE PERFORMED
NPLAN= 2 NRTIO= 1 LRTIO= 1

RTIOS= .21

********** ********** ********** ********** **********

SUB-AREA RUNOFF COMPUTATION

INFLOW TO GRANDIN RESERVOIR DAM

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
INGRD	0	0	0	0	0	1	0	0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	IRSDA	IRSPC	RATIO	ISNOW	ISAME	LOCAL
1	1	.60	0.00	.60	0.00	0.000	0	1	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.00	20.20	111.00	123.00	132.00	0.00	0.00	0.00

IRSPC COMPUTED BY THE PROGRAM IS .800

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOR	STRTL	CNSTL	ALSMX	RTIMP
0	0.00	0.00	1.00	0.00	0.00	1.00	0.00	.05	0.00	0.00

UNIT HYDROGRAPH DATA
TP= 2.25 CP= .60 NTA= 0

RECESSION DATA
STRTQ= -1.70 QRCSN= -.10 RTIOR= 2.00

UNIT HYDROGRAPH 79 END-OF-PERIOD ORDINATES, LAG= 2.24 HOURS, CP= .60 VOL= 1.00

2.	3.	16.	35.	57.	80.	96.	99.	99.	99.
99.	104.	107.	107.	104.	98.	91.	84.	78.	72.
67.	62.	58.	54.	50.	46.	43.	40.	37.	34.
32.	30.	27.	25.	24.	22.	20.	19.	17.	16.
15.	14.	13.	12.	11.	10.	10.	9.	8.	8.
7.	7.	6.	6.	5.	5.	5.	4.	4.	4.
3.	3.	3.	3.	3.	2.	2.	2.	2.	2.
1.	1.	1.	1.	1.	1.	1.	1.	1.	

END-OF-PERIOD FLOW

HO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	HO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q

SUM 21.33 20.13 1.20 44706.
(542.) (511.) (30.) (1323.98)

HYDROGRAPH ROUTING

ROUTED OUTFLOW FROM GRANDIN RESERVOIR

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
GROUT	1	0	0	0	0	1	0	0

ALL PLANS HAVE SAME ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	1	0	0	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	-686.	-1

STAGE	686.00	687.00	687.50	688.00	689.00	690.00
FLOW	0.00	120.00	203.00	535.00	1782.00	3558.00
SURFACE AREA=	0.	8.	10.			
CAPACITY=	0.	83.	117.			
ELEVATION=	653.	686.	690.			

CREL	SPWID	COOW	EXPW	ELEVL	COOL	CAREA	EXPL
686.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

DAM DATA

TOPEL	COOD	EXPD	DAMWID
687.5	0.0	0.0	0.

DAM BREACH DATA

BRWID	Z	ELBM	IFAIL	WSEL	FAILEL
60.	.01	656.00	1.50	686.00	687.50

BEGIN DAM FAILURE AT 17.33 HOURS

PEAK OUTFLOW IS 2112. AT TIME 18.06 HOURS

DAM BREACH DATA

BRWID	Z	ELBM	IFAIL	WSEL	FAILEL
50.	.01	656.00	1.50	686.00	690.00

PEAK OUTFLOW IS 264. AT TIME 18.00 HOURS

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HYDROGRAPH ROUTING

CHANNEL ROUTING TO WINCHESTER ROAD

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
OUT	1	0	0	0	0	1	0	0

ALL PLANS HAVE SAME ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	1	0	0	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	-1.	0

NORMAL DEPTH CHANNEL ROUTING

QN(1)	QN(2)	QN(3)	ELNVT	ELMAX	FLNTH	SEL
.0600	.0400	.0600	450.0	490.0	3000.	.08000

CROSS SECTION COORDINATES--STA,ELEV,STA,ELEV--ETC

0.00 490.00 105.00 460.00 165.00 470.00 215.00 460.00 250.00 450.00
280.00 460.00 330.00 480.00 360.00 490.00

STORAGE	0.00	.99	3.97	8.93	15.87	24.81	35.75	47.38	65.10	83.11
	103.45	126.34	151.83	179.91	210.59	244.29	282.06	323.96	369.97	420.11
OUTFLOW	0.00	152.35	967.39	2852.19	6142.55	11221.28	18526.06	28084.09	40157.15	54939.84
	74662.67	99499.38	127899.49	160039.01	196078.97	235688.50	279789.81	328873.34	383226.20	443132.03
STAGE	450.00	452.11	454.21	456.32	458.42	460.53	462.63	464.74	466.84	468.95
	471.05	473.16	475.26	477.37	479.47	481.58	483.68	485.79	487.89	490.00
FLOW	0.00	152.35	967.39	2852.19	6142.55	11221.28	18526.06	28084.09	40157.15	54939.84
	74662.67	99499.38	127899.49	160039.01	196078.97	235688.50	279789.81	328873.34	383226.20	443132.03

MAXIMUM STAGE IS 455.4

MAXIMUM STAGE IS 452.4

HYDROGRAPH ROUTING

ROUTED OUTFLOW AT WINCHESTER ROAD

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
WINRD	1	0	0	0	0	1	0	0

ALL PLANS HAVE SAME ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	1	0	0	0

NSTPS	NSTDL	LAG	AMSKK	X	ISK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	-381.	-1

STAGE	381.00	382.00	383.00	384.00	385.00	386.00	387.00	389.00	392.00	390.00
	391.00									
FLOW	0.00	32.00	58.00	92.00	117.00	143.00	176.00	203.00	589.00	1167.00
	3350.00									
SURFACE AREA=	0.	0.	0.							
CAPACITY=	0.	1.	2.							
ELEVATION=	381.	389.	400.							

CREL	SPWID	COOW	EXPW	ELEVL	COOL	CAREA	EXPL
391.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0

DAM DATA

TOPEL	COOD	EXPD	DAMWID
389.0	0.0	0.0	0.

PEAK OUTFLOW IS 2000. AT TIME 10.17 HOURS

PEAK OUTFLOW IS 944. AT TIME 10.00 HOURS

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HAZARD 1 0 0 0 0 1 0 0

ALL PLANS HAVE SAME ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	1	0	0	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	-1.	0

NORMAL DEPTH CHANNEL ROUTING

QN(1)	QN(2)	QN(3)	ELNVT	ELMAX	RLNTH	SEL
.0600	.0400	.0500	370.0	386.0	150.	.04000

CROSS SECTION COORDINATES--STA,ELEV,STA,ELEV--ETC

0.00 386.00 10.00 386.00 100.00 378.00 105.00 370.00 225.00 380.00
245.00 382.00 265.00 384.00 295.00 386.00

STORAGE	0.00	.02	.07	.16	.29	.45	.64	.87	1.14	1.45
	1.79	2.16	2.58	3.04	3.55	4.11	4.73	5.40	6.13	6.92
OUTFLOW	0.00	21.54	136.75	403.17	868.28	1574.29	2559.97	3861.54	5513.22	7547.65
	10214.70	13533.10	17249.25	21071.57	25427.05	31105.39	37661.50	44878.79	52901.65	61181.26
STAGE	370.00	370.84	371.63	372.53	373.37	374.21	375.05	375.89	376.74	377.58
	378.42	379.26	380.11	380.95	381.79	382.63	383.47	384.32	385.16	386.00
FLOW	0.00	21.54	136.75	403.17	868.28	1574.29	2559.97	3861.54	5513.22	7547.65
	10214.70	13533.10	17249.25	21071.57	25427.05	31105.39	37661.50	44878.79	52901.65	61181.26

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIO 1
				.21
HYDROGRAPH AT	INGRD	.60	1	266.
		(1.55)		(7.53)
			2	266.
				(7.53)
ROUTED TO	GROUT	.60	1	2079.
		(1.55)		(58.86)
			2	264.
				(7.48)
ROUTED TO	LB-1	.60	1	1997.
		(1.55)		(56.56)
			2	264.
				(7.48)
ROUTED TO	WINGD	.60	1	2000.
		(1.55)		(56.64)
			2	264.
				(7.46)
ROUTED TO	HAZARD	.60	1	2006.
		(1.55)		(56.80)
			2	264.
				(7.48)

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	381.10	381.10	388.00
STORAGE	0.	0.	1.
OUTFLOW	2.	2.	203.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.21	390.38	2.38	2.	2000.	2.00	18.17	0.00

PLAN 2

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	381.10	381.10	388.00
STORAGE	0.	0.	1.
OUTFLOW	2.	2.	203.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.21	388.33	.33	1.	264.	2.17	18.00	0.00

PLAN 1 STATION HAZARD

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.21	2006.	374.6	18.17

PLAN 2 STATION HAZARD

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS

1

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....

	ELEVATION	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
	STORAGE	686.00	686.00	687.50
	OUTFLOW	83.	83.	94.
		0.	0.	203.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.21	687.55	.05	25.	2112.	.33	18.06	17.33

PLAN 2 .....

	ELEVATION	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
	STORAGE	686.00	686.00	687.50
	OUTFLOW	83.	83.	94.
		0.	0.	203.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.21	687.59	.09	95.	264.	2.33	18.00	0.00

PLAN 1 STATION LB 1

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.21	1997.	455.4	18.17

PLAN 2 STATION LB 1

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS

1

SUMMARY OF DAM SAFETY ANALYSIS - 15-Min Breach
(Meredith School Retention Dam)

PLAN 1 w/breach

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	686.00	686.00	687.50
STORAGE	83.	83.	94.
OUTFLOW	0.	0.	203.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.21	687.54	.04	95.	9196.	.21	17.54	17.33

PLAN 2 w/o breach

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	686.00	686.00	687.50
STORAGE	83.	83.	94.
OUTFLOW	0.	0.	203.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.21	687.59	.09	95.	264.	2.33	18.00	0.00

PLAN 1 STATION LB-1

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.21	5879.	458.3	17.50

PLAN 2 STATION LB-1

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.21	264.	452.4	18.00

SUMMARY OF DAM SAFETY ANALYSIS

(@ Winchester Road)

PLAN 1 ..w/breach..

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	381.10	381.10	388.00
STORAGE	0.	0.	1.
OUTFLOW	2.	2.	283.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.21	391.35	3.35	3.	5402.	.50	17.50	0.00

PLAN 2 ..w/o breach..

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	381.10	381.10	388.00
STORAGE	0.	0.	1.
OUTFLOW	2.	2.	283.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.21	387.82	0.00	1.	264.	0.00	18.00	0.00

PLAN 1 STATION HAZARD

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.21	5342.	376.6	17.50

PLAN 2 STATION HAZARD

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.21	264.	372.1	18.00

NOT AVAILABLE AT THIS TIME

END